Millers Falls Handbook *for* Mechanics

MILLERS FALLS TOOLS

Millers Falls Handbook
for
Mechanics

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MILLERS FALLS COMPANY
MILLERS FALLS, MASS.

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INTRODUCTION

Usability has been the determining factor in selecting the information which has been brought together in this, the first issue of the Millers Falls Mechanics' Handbook.

Our aim has been to get right down to solid, worthwhile useful *facts*. Lengthy technical descriptions have been left out. Everything possible has been done to make the tables, formulas, and general descriptions easily understood and easily applied.

If this information enables you to accomplish anything new, or do your work more easily, more quickly, or more accurately, we will feel many times repaid for the labor involved in collecting and arranging this material for your use.

Incidentally, we would kindly ask you to recall occasionally that it has been the experience of many of the most skilled and most successful mechanics and tool users that Millers Falls Tools, because of their many improvements and genuine quality and accuracy, are a big assistance in doing the best work possible in the most convenient manner.

MILLERS FALLS COMPANY.

BOARD MEASURE

A board one inch or less in thickness is said to have as many board feet as there are square feet in its surface. For boards more than one inch thick, multiply the number of square feet in its surface by the thickness in inches and fractions of an inch.

Board measure is used in measuring planks. A plank 3 inches thick, 15 feet long, and 10 inches wide contains three times as many board feet as a board 1 inch thick of the same length and width.

In measuring boards many people multiply the length in feet by the width in inches, and divide by 12; if more than 1 inch thick, multiply the above result by the thickness in inches.

Weight per Foot of Wood, Board Measure.

The following gives the approximate weight of various kinds of woods known to the trade as dry timber:

			Lbs.
White oak	4.16	Spruce	2.30
White pine	2.30	Cypress	3.11
Douglas fir	2.65	Cedar	2.97
Short leaf yellow pine	2.65	Chestnut	3.12
Red pine	2.60	Georgia yellow pine	3.17
Hemlock	2.08	California spruce	2.30

WOOD STAINING

The best woods for staining are those having close grain, such as maple, birch, and cherry. In order to get best results the wood must be perfectly dry, planed, and sandpapered very smooth. Many of the stains are applied hot, as this means a deeper penetration. If the natural color of the wood is such as to prevent satisfactory results, the wood may be bleached by applying the following solution: Water, 2½ quarts; chloride of lime, 9 ounces; soda crystals, 1 ounce. Apply to the wood; after

bleaching for half an hour wash with a solution of sulphurous acid, then with clear water. Allow the surface to dry, then apply the desired stain.

To Darken Oak

(1) Oak may be darkened by applying strong ammonia by means of a sponge or brush.

(2) Another method of darkening oak is to apply bichromate of potash dissolved in a small quantity of water.

(3) Some cabinetmakers darken oak by means of a coffee solution. This is made by boiling coffee in water, making a strong solution.

(4) A strong solution of salsoda will darken oak. As this raises the grain, it should be sandpapered and oiled afterwards.

(5) Any shade of darkness may be given oak by applying a mixture of fine iron filings mixed with a little water and sulphuric acid; this should be applied with a sponge. The shade is determined by the number of applications. Each coat should be allowed to dry thoroughly before applying the next.

(6) *New oak* may be given any shade of darkness, even black, by applying a stain made by boiling green walnut shells in water.

Brown Stain on Oak

Add 2 parts each of American potash and pearlash to 1½ parts boiling water. Apply with a swab made by fastening cloth or a sponge to a stick; dilute the mixture with water if necessary to get the desired shade. Do not allow the hands to come in contact with the mixture, as it will burn the flesh.

To Stain Pine a Walnut Color

Mix thoroughly 1 pound dry burnt sienna, 1 pound dry burnt umber, and 4 ounces lamp black; add to 1 gallon of very thin size shellac. Apply with a brush. When thoroughly dry rub down with fine glass-paper and then give one coat of shellac or varnish.

Walnut Stain

Dissolve in 30 ounces of water 1 ounce of permanganate of potash. Apply this solution twice. Wait a few minutes and wash with clean water; when dry, oil and polish.

Walnut Stain for Hard Wood

To 1 gallon of strong vinegar add 1 pound dry burnt umber, ½ ounce rose pink, and ½ pound dry burnt Vandyke brown. Mix thoroughly and apply with a brush.

Rosewood Color

Boil in ½ gallon of water, 1 pound logwood chips and ½ pound red sandalwood. Apply to the wood, then go over it with a mixture of asphaltum and turpentine.

To Give the Appearance of Age to New Wood

Boil in 1 gallon of water 2 ounces of logwood chips and ½ pound madder; brush the solution on while hot. Allow the surface to dry, then go over it with a solution made by adding 2 drams pearlash to 1 quart water.

To Stain Woods Black

Add 1 ounce of powdered logwood to 3¼ pints of water. Boil for a while, or until the logwood is dissolved, then add 1 dram of yellow chromate of potash; stir well. Almost any wood can be given a fine black with this mixture.

PUTTY AND CEMENTS FOR WOOD

Soft Putty. — To 10 pounds of whiting add 1 pound white lead and the necessary quantity of boiled linseed oil. After mixing well, add ½ gill good quality olive oil. This putty will stick well, and does not easily crack.

Wax Putty. — For leaky casks, etc.: Tallow, 2 pounds; yellow wax, 4 pounds; spirits turpentine, 1 pound; solid turpentine, 6 pounds. Melt the wax and solid turpentine over a gentle fire; add the tallow. When melted remove to a place remote from the fire, add the spirits of turpentine; when cool it is ready for use.

Mahogany Cement. — Melt 4 ounces beeswax, add 1 ounce Indian red and enough yellow ochre to give the desired tint.

Cementing Wood to Metals. — Dissolve a good quality of glue in boiling water to the consistency of cabinet makers' glue; add, while stirring wood ashes, until a varnishlike mixture is produced. Use hot.

GLUE

Glue to Resist Moisture. — One pound good flake glue melted in 2 quarts of skim milk.

Glue Cement to Resist Moisture. — Four parts good glue, 4 parts black resin, 1 part red ochre. Mix with least possible quantity of water.

Marine Glue. — One part of India rubber, 12 parts of mineral naphtha or coal tar. Heat gently, mix, and add 20 parts powdered shellac. Pour out on a slab to cool. When used, it should be heated to about 250° F.

PINE SHINGLES

Number and Weight of Shingles to Cover one Square of Roof.

1 square = 100 square feet.

Number of inches exposed to weather . .	4	4½	5	5½	6
Number of shingles per square of roof . .	900	800	720	655	600
Weight of shingles on one square in pounds	216	192	173	157	144

The number of shingles per square is for common gable roofs. For hip roofs add 5 per cent to these figures. A bundle contains 250 shingles; 1000 four-inch shingles weigh 240 pounds.

SHINGLE NAILS

Size	Length Inches	Approximate No. to Lb.	Size	Length Inches	Approximate No. per Lb
3d	1¼	429	7d	2¼	139
4d	1½	274	8d	2½	125
5d	1¾	235	9d	2¾	114
6d	2	204	10d	3	83

FINISHING NAILS

Size	Length Inches	Approximate No. per Lb.	Size	Length Inches	Approximate No. per Lb.
2d	1	1351	8d	2½	189
3d	1¼	807	9d	2¾	172
4d	1½	584	10d	3	121
5d	1¾	500	12d	3¼	113
6d	2	309	16d	3½	90
7d	2¼	238	20d	4	62

COMMON NAILS

Size	Length Inches	Approximate No. per Lb.	Size	Length Inches	Approximate No. per Lb.
2d	1	876	10d	3	69
3d	1¼	568	12d	3¼	63
4d	1½	316	16d	3½	49
5d	1¾	271	20d	4	31
6d	2	181	30d	4½	24
7d	2¼	161	40d	5	18
8d	2½	106	50d	5½	14
9d	2¾	96	60d	6	11

FINE NAILS

2d	1	1351	3d extra fine	1⅛	1015
3d	1⅛	778	4d	1½	473

NUMBER OF WROUGHT SPIKES IN KEG OF 150 POUNDS

Length Inches	¼ in. dia.	5⁄16 in. dia.	⅜ in. dia.	Length Inches	¼ in. dia.	5⁄16 in. dia.	⅜ in. dia.	7⁄16 in. dia.	½ in. dia.
3	2250	....	....	7	1161	662	482	445	306
3½	1890	1208	....	8	....	635	455	384	256
4	1650	1135	....	9	....	573	424	300	240
4½	1464	1064	....	10	....	....	391	270	222
5	1380	930	742	11	....	....	....	249	203
6	1292	868	570	12	....	....	....	236	180

FILING HAND SAWS

The best tool obtainable can become a poor tool if not given proper care and attention. The ordinary hand saw is a good example of how satisfactory or unsatisfactory a tool may become by being properly or improperly sharpened and set.

In sharpening an ordinary cross cut saw the first operation is "jointing." This is done by cutting down the ends of the teeth with a mill file until they are all of the same length. This can be determined, in the case of a straight breasted saw by means of a straight edge. The teeth should now be given the proper amount of set. If a setting block is at hand it should be used; the block should *not* have a sharp corner at the junction of the flat and bevel where the tooth bends, or the tooth may be broken in the setting operation. Do not give the tooth *too much* set, a slight turning of the point, just enough to insure the kerf being wide enough to allow the saw to work freely is sufficient. If the workman is skillful in the use of the file it is a good plan to side file the teeth to offset the effect of uneven setting.

To file the teeth, place the saw in the vise, not allowing the teeth to project very much above the top of vise. File the teeth that have the set away from you, commencing the filing at the point of the saw, and working toward the butt, or heel. The bevel should be given to the side opposite the set; that is, the front of the tooth as it stands in the vise. The amount of bevel cannot be stated arbitrarily, but must be according to the judgment of the workman. When one side is filed reverse the saw in the vise and proceed with the other side.

When filing a six or seven point saw, use a 7-inch slim taper three square file; for eight and nine point, use a 6-inch slim taper; for a ten, eleven, and twelve point, use a 5-inch slim taper.

When filing rip saws follow instructions given for cross cut. However, in case of saws that are to be used for ordinary and hardwoods, file straight across; for soft woods a slight bevel is advisable.

To remove any burr or wire edge occasioned by the filing, and to insure a keen cutting edge, it is well to pass a hard oilstone lightly along the sides of the teeth.

Bearing these general instructions in mind, it would be well for you to watch a professional file setter at work, if the opportunity offers. It will convince you that "there are tricks in all trades." To see this work done will do much to make it easier for you.

AMOUNT OF PAINT TO COVER A SURFACE

It is impossible to give a rule that will apply in all cases, as the amount necessary varies with the quality of the paint, the kind and condition of the wood, or other material etc. One gallon of paint will cover 250 to 400 square feet, first coat, and from 350 to 500 square feet as a second coat.

APPROXIMATE WEIGHTS OF VARIOUS ROOF COVERINGS

For preliminary estimates the weights of various roof coverings may be taken as below:

	lbs.
Cast-iron plates, 3/8 inch thick	1500*
Copper	80-125
Felt and asphalt	100
Felt and gravel	800-1000
Iron corrugated	100-375
Iron galvanized flat	100-350
Lath and plaster	900-1000
Sheathing, pine 1 inch thick, yellow northern .	300
Sheathing, pine 1 inch thick, yellow southern	400
Spruce, 1 inch thick	200
Sheathing, chestnut or maple, 1 inch thick .	400
Sheathing, ash, hickory, or oak, 1 inch thick .	500
Sheet iron, 1/16 inch thick	300
Sheet iron, 1/16 inch thick, and laths . . .	500
Shingles, pine	200
Slate, 1/4 inch thick	900
Sheet lead	500-800
Tin	70-125
Tiles, flat	1500-2000
Tiles, grooves, and fillets	700-1000
Tiles, pan	1000
Tiles, with mortar	2000-3000
Zinc	100-200

*These figures are based on the unit of roofing measurements, the "*square*," or 100 square feet, a "square" being 10 feet x 10 feet.

BRICKWORK

Brickwork is estimated by the thousand, and of various thickness of wall, runs as follows:

8¼-inch wall, or 1 brick in thickness, 14 bricks per superficial (surface) foot.

12¾-inch wall, or 1½ bricks in thickness, 21 bricks per superficial foot.

17-inch wall, or 2 bricks in thickness, 28 bricks per superficial foot.

21½-inch wall, or 2½ bricks in thickness, 35 bricks per superficial foot.

An ordinary brick measures about 8¼ x 4 x 2 inches, which is equal to 66 cubic inches, or 26.2 bricks to a cubic foot. The average weight is 4½ pounds.

STONEWORK

The "perch" (24¾ cubic feet) is the unit by which stone walls are measured. Openings over 3 feet are deducted; those less than 3 feet counted as solid, but 18 inches are added to the running measure for each jamb. Arches are counted solid from their spring. Corners of buildings are measured twice. Pillars less than 3 feet are counted on three sides as lineal, multiplied by fourth side and depth.

It is customary to measure all foundation and dimension stone by the cubic foot, water tables and base courses by lineal feet, all sills and lintels or ashler by superficial feet.

WEIGHTS AND MEASURES

LONG MEASURE

12 inches	= 1 foot
3 feet	= 1 yard
5½ yards, or 16½ feet	= 1 rod, pole, or perch
40 rods, or 220 yards	= 1 furlong
8 furlongs, or 5280 feet	= 1 mile
3 miles	= 1 league

SURVEYORS' MEASURE

7.92 inches	= 1 link
25 links	= 1 rod
4 rods, 100 links, 66 feet	= 1 chain
80 chains	= 1 mile

SQUARE MEASURE

144 square inches	= 1 square foot
9 square feet	= 1 square yard
30¼ square yards, or 272¼ square feet	= 1 square rod, pole, or perch
40 square rods	= 1 rood
4 roods, or 160 square rods, or 4840 square yards, or 43560 square feet	= 1 acre
640 acres	= 1 square mile

An acre equals a square whose side is 208.71 feet.

AVOIRDUPOIS OR COMMERCIAL WEIGHT

16 drams	= 1 ounce
16 ounces	= 1 pound
2000 pounds	= 1 net or short ton
2240 pounds	= 1 gross or long ton

Below are given several measures for weights now seldom used in the United States.

1 stone	= 14 pounds
1 quarter	= 28 pounds
1 quintel	= 100 pounds
4 quarters	= 112 pounds (called 1 hundredweight)

20 hundredweight (of 112 pounds) = 1 gross or long ton = 2240 pounds

TROY WEIGHT

24 grains	= 1 pennyweight
20 pennyweights	= 1 ounce
12 ounces	= 1 pound

1 carat (used in weighing diamonds) = 3.168 grains

1 grain troy = 1 grain avoirdupois = 1 grain apothecaries' weight

APOTHECARIES' WEIGHT

20 grains	= 1 scruple
3 scruples	= 1 dram
8 drams	= 1 ounce
12 ounces	= 1 pound

APOTHECARIES' FLUID MEASURE

60 minims = 1 fluid dram
8 drams = 1 U. S. fluid ounce
1 U. S. fluid ounce = 1.805 cubic inch = 1/128 U. S. gallon
1 British fluid ounce = 1.732 cubic inch

CIRCULAR MEASURE

60 seconds (″) = 1 minute (′)
60 minutes (′) = 1 degree (°)
90 degrees (°) = 1 quadrant
360 degrees (°) = circumference

UNIT MEASURE

12 units = 1 dozen
12 dozen = 1 gross
12 gross = 1 great gross
20 units = 1 score

SOLID OR CUBIC MEASURE

1728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
1 cord of wood = a pile. 4 x 4 x 8 feet = 128 cubic feet
1 perch of masonry = 16½ x 1½ x 1 foot = 24¾ cubic feet

SHIPPING MEASURE

Used in measuring entire internal capacity of a vessel
1 register ton = 100 cubic feet
For measurement of cargo the following is used:
1 U. S. shipping ton = 40 cubic feet = 32.143 U. S. bushels = 31.16 imperial bushels.
1 British shipping ton = 42 cubic feet = 33.75 U. S. bushels = 32.72 imperial bushels.

LIQUID MEASURE

4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 U. S. gallon
1 U. S. gallon = 1.337 cubic feet = 231 cubic inches
1 cubic foot = 7.48 U. S. gallons
1 British imperial gallon = 1.2003 U. S. gallon = 277.27 cubic inches
1 gallon of water at 39.1° F. weighs 8.3389 pounds, which is approximately 8⅓ pounds.
1 cubic foot of water weighs 62.355 pounds.

DRY MEASURE

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel

1 bushel (U. S. or Winchester struck bushel) = 1.2445 cubic foot = 2150.42 cubic inches.
1 heaped bushel = $1\frac{1}{4}$ struck bushel
1 cubic foot = 0.8036 struck bushel
1 British imperial bushel = 8 imperial gallons = 2218.19 cubic inches

MENSURATION

To Find Circumference of a Circle, Diameter Given

Multiply diameter by 3.1416. Or, divide diameter by 0.3183.

To Find Diameter of a Circle, Circumference Given

Multiply circumference by 0.3183. Or, divide circumference by 3.1416.

To Find Radius of a Circle, Circumference Given

Multiply circumference by 0.15915. Or, divide circumference by 6.28318.

To Find Area of a Circle

Multiply the square of the radius by 3.1416. Or, multiply the square of the diameter by .7854. Or, multiply the square of the circumference by 07958. Or, multiply the circumference by one-quarter of the diameter.

To Find the Area of the Sector of a Circle

Multiply the length by one-half the radius.

To Find the Area of a Circular Ring

Subtract the area of the inner circle from the area of the outer. Or, multiply the sum of the diameters of the two circles by the difference of the diameters, and that product by .7854.

To Find the Area of an Ellipse

Multiply the product of the two diameters by .7854.

To Find the Area of a Parabola

Multiply the base by two thirds of the altitude.

To Find the Area of a Triangle

Multiply the base by one half the altitude.

To Find the Area of a Parallelogram

Multiply the base by the altitude.

To Find the Area of a Trapezoid

Multiply the altitude by one-half the sum of parallel sides.

To Find the Area of a Trapezium

Divide the figure into two triangles and find the area of the triangles.

To Find the Area of a Circular Segment

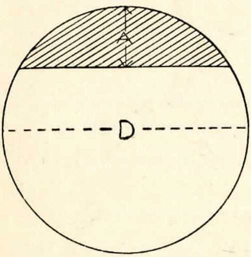


Fig. 1

This rule is used in finding the steam space in boilers, also in finding the quantity of liquid contained in partially filled tanks. To find the area (Fig. 1) of the shaded portion, the height A and diameter D must be known. Then proceed to find the area of the arc by use of formula where $\frac{4A^2}{3}\sqrt{\frac{D}{A}-.608}$ = area of circular segment.

COMMON GEOMETRICAL PROBLEMS

To Inscribe a Hexagon in a Circle (Fig. 2)

Draw a line across the center A, C, B, using A and B as centers with the radius of the circle AC; cut the circumference, at D, E, F, G, and draw the lines AD, DE, etc., thus forming the hexagon. The radius of the circle is the length of one side of the hexagon.

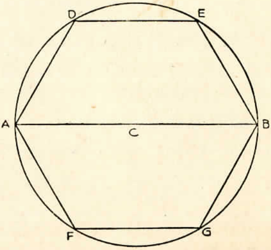


Fig. 2

To Inscribe an Octagon in a Circle (Fig. 3)

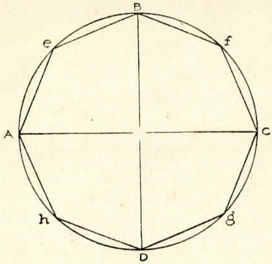


Fig. 3

Draw two diameters *AC* and *BD* at right angles; bisect the arcs *AB*, *BC*, etc., at *e*, *f*, *g*, and *h*; connect these points with lines *e B*, etc., to form the octagon.

To Describe a Polygon of Any Number of Sides upon a Given Straight Line (Fig. 4)

Draw the line *A B*, the length of one side of the desired figure, and on *A*, with the radius *A B*, describe a semicircle as shown; divide the semicircumference into as many equal parts as there are to be sides in the polygon, in this instance, five sides. Draw lines from *A* through the divisional points *D*, *b*, and *c*, omitting *a*: and on the center *B* and *D*, with the radius *A B*, cut *Ab* at *E* and *Ac* at *F*. Draw sides *DE*, *EF*, and *FB* to complete the five-sided figure (pentagon).

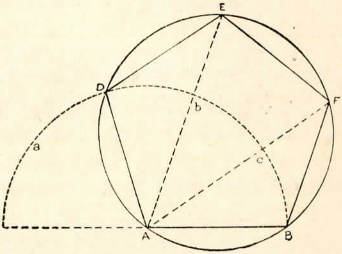


Fig. 4

To Find the Capacity of a Cylindrical Tank

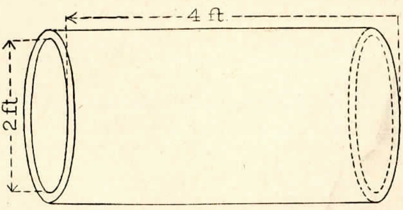


Fig. 5

A cylindrical tank 2 feet diameter and 4 feet high is shown in Fig. 5. To find its capacity, multiply the square of the diameter by .7854, and multiply the product by the height. Always bear in mind that like quantities must be considered together; do not multiply inches by feet, but by inches, and feet by feet.

Example. — How many gallons will the tank shown hold?

Solution.— 2 squared $= 2 \times 2 = 4$ $4 \times .7854 = 3.1416$ $3.1416 \times 4 = 12.5664$ cubic feet.

According to the table of liquid measure 1 cubic foot contains 7.48 gallons. $12.5664 \times 7.48 = 93.99$ gallons.

INCLINED PLANE

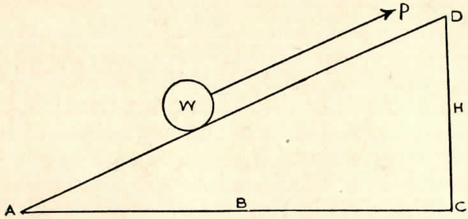


Fig. 6

The *inclined plane* is a flat surface inclined to the horizontal. With the inclined plane a weight can be raised by a force less than its own magnitude, as Fig. 6 will show.

The weight W is to be raised from a horizontal AC to D. If the weight is raised vertically as from C to D, then weight (W) and force (P) are equal. But if the weight is moved up the incline AD the force acts through the distance AD while the weight is lifted only the distance CD; and the statement becomes $P : W = CD : AD$ and the formulas obtained are, —

$$P = \frac{W \times H}{L}$$

and

$$W = \frac{P \times L}{H}$$

If the force acts along a line parallel to the base, AC then $P : W =$ height : base
and the formulas obtained are. —

$$P = \frac{W \times H}{B}$$

and

$$W = \frac{P \times B}{H}$$

Where P = force
W = weight
H = height
L = length of incline
B = length of base

Example 1. — What weight can be moved up an incline 10 feet long and 5 feet high with a force of 300 pounds applied parallel to the incline?

Solution. —

$$W = \frac{P \times L}{H} = W = \frac{300 \times 10}{5} = 600 \text{ pounds. Ans.}$$

Example 2. — What weight can be moved up an incline whose base is 12 feet long and 7 feet high with a force of 125 pounds applied parallel to the base?

Solution. —

$$W = \frac{P \times B}{H} = W = \frac{125 \times 12}{7} = 214\tfrac{2}{7} \text{ pounds. Ans.}$$

AVERAGE WEIGHTS AND VOLUMES OF FUELS

Anthracite coal, 1 cubic foot = 55 to 65 pounds
1 ton (2240 pounds) = 34 to 41 cubic feet
Bituminous coal, 1 cubic foot = 50 to 55 pounds
1 ton (2240 pounds) = 41 to 45 cubic feet
Charcoal, 1 cubic foot = 18 to 18½ pounds
1 ton (2240 pounds) = 120 to 124 cubic feet
Coke, 1 cubic foot = 28 pounds
1 ton (2240 pounds) = 80 cubic feet.

The average weight of a bushel of anthracite coal is 67 pounds; of a bushel of bituminous coal, 60 pounds; of a bushel of charcoal, 20 pounds; of a bushel of coke, 40 pounds.

Weight of Wood. — One cord of seasoned wood is 128 cubic feet, and weighs approximately as follows: Beech, 3200 pounds; chestnut, 2300 pounds; elm, 2400 pounds; maple, 4500 pounds; poplar, 2300 pounds; pine, 2000 pounds; oak, red or black, 3300 pounds; oak, white, 3800 pounds.

Fahrenheit and Centigrade Thermometer Scales

Every one is familiar with the Fahrenheit thermometer and its readings, but comparatively few are familiar with

the significance of the centigrade scale. At the present time many of the heat-measuring instruments are graduated to centigrade readings. To convert the readings from one scale to the other use the following rules.

To Convert Fahrenheit to Centigrade Readings

Subtract 32 from the Fahrenheit, divide the remainder by 9 and multiply by 5.

Example. — Convert 212° F. to C. equivalent. $212 - 32 = 180$. $180 \div 9 = 20$. $20 \times 5 = 100°$ 212° F. and 100° C. are the respective readings of the temperature at which water boils.

To Convert Centigrade to Fahrenheit Readings

Divide Centigrade reading by 5, multiply by 9, and add 32.

Example. — Convert 100° C. to F. equivalent.

$100 \div 5 = 20$ $20 \times 9 = 180$ $180 + 32 = 212°$

COEFFICIENT OF EXPANSION FOR THE FOLLOWING SUBSTANCES

Substance	Linear Expansion	Surface Expansion	Cubic Expansion
Alcohol	.00019259	.00038518	.00057778
Brass	.00001037	.00002074	.00003112
Copper	.00000955	.00001910	.00002864
Bar iron	.00000686	.00001372	.00002058
Cast iron	.00000617	.00001234	.00001850
Mercury	.00003334	.00006668	.00010010
Silver	.00000690	.00001390	.00002070
Steel, soft	.00000599	.00001198	.00001798
Steel, hardened	.00000702	.00001404	.00002106
Tin	.00001410	.00002820	.00003229
Zinc	.00001634	.00003268	.00004903

Example. — A soft steel bar 10 feet long is heated from 60° to 300°. How much will it lengthen?

Solution. — $10\,(300-60) \times .00000599 = .014376$ foot, or $.014376 \times 12 = .1725$ inch.

COMPOSITION OF COMMON ALLOYS

Alloy	Composition
Babbitt's metal	Copper 5, Tin 25, Antimony 2
Bell metal	Copper 16, Tin 4

Aloy	Composition
Brass castings, soft	Copper 20, Tin 2.5, Zinc 1.25
Brass castings, hard	Copper 25, Tin 4.5, Zinc 2
Brass to be rolled	Copper 32, Tin 1.5, Zinc 10
Brass, yellow	Copper 2, Zinc 1
Britannia metal	Antimony 50, Tin 25, Bismuth 25
Gun bronze	Copper 88, Tin 9, Zinc 2, Iron .06, Lead .2
Gun metal	Copper 8, Tin 1
Hard gun metal	Copper 16, Tin 2.5
Journal bronze	Copper 83, Tin 13, Zinc 3, Iron .06, Lead 1
Manganese bronze, cast	Copper 56.11, Tin .75, Zinc 41.34, Iron 1.3, Lead .02, Aluminum .47, Manganese .01
Muntz metal	Copper 60, Zinc 40
Phosphor bronze	Copper 90, Phosphor tin 10
Phosphor bronze	Copper 92, Phosphor tin 8
Tobin bronze	Copper 59, Tin 2.16, Zinc 38.4, Iron .11 Lead .31
White metal, hard	Copper 35, Tin 2.2, Zinc 13
White metal, ordinary	Copper 3.7, Tin 14.2, Zinc 3.7, Antimony 28.4
Metal to expand in cooling	Lead 75, Antimony 16.7, Bismuth 8.3

BOILERS

There are two classes of boilers in general use; namely, water tube and fire tube. In the water tube boiler the water is contained in the tubes and the fire circulates outside. In the fire tube boiler the water is contained in the shell of the boiler and the fire passes through the tubes which are in the water and attached to the heads.

The return tubular boiler is very widely used in the United States, and is a type of fire tube boiler.

Boilers up to fourteen feet in length are made of two plates, each forming one-half the length of the boiler; above fourteen feet three plates are used to give the total length. These plates are ¼, ⅜, ½, or 9/16 inch thick.

Tensile Strength.

The tensile strength of any material is the lengthwise strain in pounds necessary to break the piece. It is generally stated in one square inch of area. The tensile strength of steel used in boiler plates varies. In some states it is fixed by law. In one state it must not be less than 52,000 pounds or more than 63,000 pounds per square inch.

Boiler Construction.

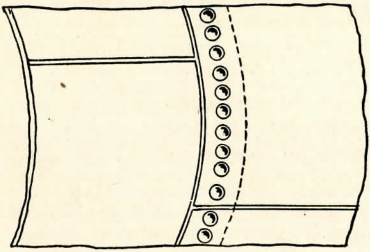


Fig. 7

At the present time most fire tube boilers made to generate steam for engines have the different portions of the shell overlapping one another as shown in Fig. 7, and are held with a single row of rivets. This is called a *lap* joint.

Lap joints are not used to any great extent in joining the two *ends* of the same sheet. The ends are brought together and a strap is placed on the inside and another on the outside, as shown in Fig. 8; this is called a butt

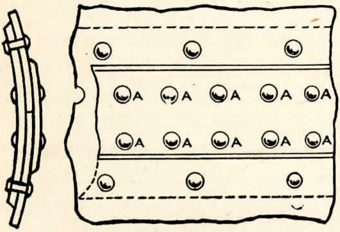


Fig. 8

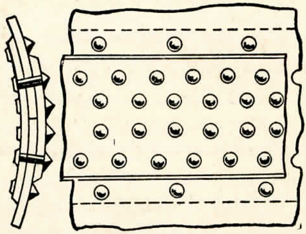


Fig. 9

joint. These straps and the plate are joined by riveting, as shown. If a *single* row of rivets is used on each side of the joint through the *outer* plate, as shown at *AA*, it is called a single-riveted butt joint.

If a double row is placed on each side of the joint through the outer strap, as shown in Fig. 9, it is called a double-riveted butt joint; if three rows are used, it is called a triple-riveted butt joint.

The Plate.

The Boiler Inspection Department of Massachusetts recommends the following formula for determining the thickness of boiler plate:

$$T = \frac{P \times R \times FS}{TS \times \%}$$

Where T = thickness of boiler plate
P = boiler pressure
R = radius (½ diam. of boiler)
FS = factor of safety
TS = tensile strength
$\%$ = strength of joint

Example. — What thickness of plate should be used when making a 40-inch diameter boiler to carry 125 pound pressure, if the strength of the plate is 60,000 pounds per square inch, using a factor of safety of 6, and 50% as the strength of joint?

Solution. —

$$T = \frac{125 \times 20 \times 6}{60000 \times .50} = \tfrac{1}{2} \text{ inch sheet}$$

To Find the Safe Working Pressure.

Use the following formula where the letters have the same significance as in the previous formula.

$$P = \frac{TS \times \% \times T}{R \times FS}$$

Example. — Find the safe working pressure of the same boiler.

$$P = \frac{60000 \times .50 \times .5}{20 \times 6} = 125 \text{ pounds. Ans.}$$

SAFETY VALVE

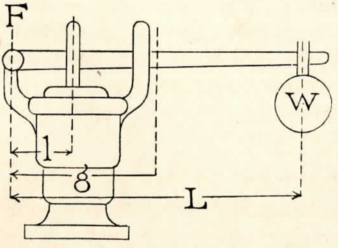


Fig. 10

Fig. 10 shows a lever safety valve; and calculations for lengths of arms and weights required for any boiler pressure are obtained from the formulas for levers. It is also necessary to take into account the weight of lever and valve.

The center of gravity is the point at which the lever and valve attached to it will just balance over a balancing

bar (bar with knife edge); the fulcrum is at center of pivot on which the lever works.

In Fig. 10 F is the fulcrum on which lever works

W = weight of ball in pounds

G = distance in inches from fulcrum to center of gravity

Vl = weight of valve and lever in pounds

L = distance between ball and center of fulcrum in inches

l = distance between fulcrum and center of valve in inches

P = boiler pressure per square inch

A = area of safety valve in square inches

Then $$W = \frac{A \times P \times l - Vl \times g}{L}$$

and $$L = \frac{A \times P \times l - (Vl \times g)}{W}$$

Example. — At what distance from the center of fulcrum must a weight be placed, if the boiler pressure is 100 pounds, weight is 16 pounds, area of valve is 3 square inches, and valve and lever weigh 16 pounds, center of valve is 2½ inches from fulcrum, and center of gravity is 12 inches from fulcrum?

Solution. —

$$\frac{3 \times 100 \times 2\tfrac{1}{2} - (16 \times 12)}{16} = 34\tfrac{7}{8} \text{ inches.}$$

Pop Safety Valve.

The pop safety valve is very commonly used. Instead of the lever and weight used in the lever valve, a coil spring is employed to hold the valve onto the seat.

The size of the safety valve that should be used on a boiler may be found by the following rule:

Where G = grate surface

P = boiler pressure

Then $$\frac{G \times 22.5}{P + 8.62} = A$$

Divide area by .7854 and extract the square root of the quotient. The result is the diameter.

PUMPS

Pumps are of several kinds and are operated by hand or power. In North America the capacity of a pump is usually figured in *United States standard gallons.* The standard gallon contains four liquid quarts, or 231 cubic inches. Figuring distilled water at its maximum density the weight of a U. S. standard gallon is 8.3389 pounds. 8⅓ pounds is the commonly accepted standard of weight per gallon, and with the exception of when exceedingly large volumes are figured gives a very close approximation, — a working approximation for all practical purposes. There are 7.4805 gallons in a cubic foot. The formula for lifting or forcing water either under pressure or head is as follows: $P = HAW$, where H is the distance from the level of the source of supply to the point of discharge.

A = area in square feet of surface in contact with the water.

W = weight of a cubic foot of water = 62.5 pounds.

Example. — What is the pull on a pump rod, when diameter of bucket is 6 inches and water is raised 20 feet?

$$P = HAW = 20 \times \frac{6^2 \times .7854}{144} \times 62.5 = 245.437 \text{ lbs.}$$

From the above solution we find that the pull on pump rod is 245.437 pounds; to this must be added the amount of power necessary to overcome friction.

The steam pump is commonly used in power plants to supply feed water to the boiler. Ordinarily these pumps are made with a steam piston at one end and a water piston at the other. The steam piston must be enough larger than the water piston to furnish power enough to overcome friction of the moving parts, and valve leakage, and also to force water into the boiler against boiler pressure. The necessary allowance for friction varies from 5% to 40%.

When a pump takes water on one end only of piston, it is called a *single* action pump; when water is taken on both ends, it is called a *double* action pump.

To Find the Capacity of a Pump per Hour

Rule. — Find the cubical contents of the water cylinder

per stroke in cubic inches, multiply by number of strokes per hour, and divide the product by 231 to find the number of gallons, or by 1728 to find the capacity in cubic feet.

Example. — What is the capacity per hour of a single action pump with a water piston 6 inches diameter and 10 inches stroke, when the piston makes 60 strokes per minute?

Solution. — If the water cylinder is filled at each stroke, the contents are $A \times L = 28.274 \times 10 = 282.74$ cubic inches.

At 60 strokes per minute there will be $60 \times 60 = 3600$ strokes per hour. If the piston pumps 282.74 cubic inches per stroke, then for one hour it will pump

$282.74 \times 3600 = 1017864$ cubic inches per hour,

or $1017864 \div 1728 = 589$ cubic feet per hour,

or $1017864 \div 231 = 4406.33$ gallons per hour.

To Find H.P. Required to Pump Water to a Given Height

Rule. — Multiply the weight in pounds of water to be raised per minute by the height in feet and divide by 33,000; the quotient will be the H.P. required.

The formula is $H.P. = \dfrac{W \times H}{33000}$

Example. — Find the *H.P.* required to pump 4406.33 gallons water per hour to a height of 40 feet above source of supply.

Solution. — If a pump will raise 4406.33 gallons of water per hour, it will raise $4406.33 \div 60 = 73.438$ gallons per minute, and as 1 gallon water weighs $8\frac{1}{3}$ pounds, 73.438 gallons weigh $73.438 \times 8\frac{1}{3} = 611.983$ pounds. This weight of water is to be raised 40 feet high: then by formula

$$H.P. = \frac{W \times H}{33000} = \frac{611.983 \times 40}{33000} = \frac{24479.32}{33000} = .741\ H.P.$$

Notes in Regard to Pumps

Note 1. — The average piston speed of cold water pumps is 100 feet per minute.

Note 2. — In cold weather open all cocks and drain plugs to prevent freezing.

Note 3. — Use *good* cylinder oil only, and oil steam end, just before stopping pump.

Note 4. — Always see that the pump has a full and steady supply of water.

Note 5.— Keep stuffing boxes full of good packing, well lubricated, just tight enough to prevent leakage without excessive friction.

DYNAMOMETER

Dynamometers are instruments used to weigh the power necessary to operate machines.

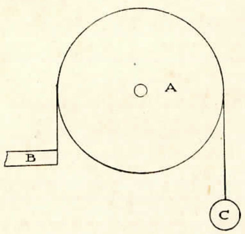


Fig. 11

The *Prony brake* is one of the most simple and familiar examples of the dynamometer. Fig. 11 represents a type of Prony brake where a fixed band of leather, or rope, is in contact with a portion of the circumference of a pulley or drum *A*. The band has one end attached as shown, at *B*, while the weight *C* is hung at the other end.

The formula is, —

$$\left.\begin{array}{l}\text{Foot-pounds}\\\text{per minute}\end{array}\right\} = \frac{3.1416 \times \text{diam. of pulley} \times \text{rev. per minute}}{12} \times \text{weight}$$

Example.—The pulley of a band brake is 126.04 inches diameter, makes 200 revolutions per minute; a weight of 5 pounds hung at end of band just affects the speed, what is the *H.P.?*

Solution. —

$$H.P. = \frac{3.1416 \times 126.04 \times 200}{12} \times 5 = 33{,}000 \text{ ft.-lbs. per min.} = 1\ H.P.$$

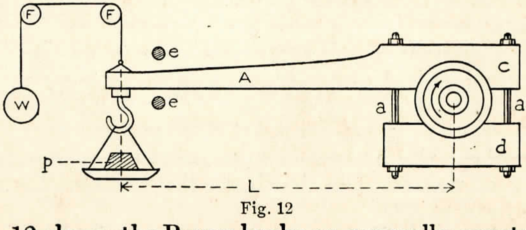


Fig. 12

Fig. 12 shows the Prony brake as generally constructed. The clamp shoes *c* and *d* are clamped to the pulley with

bolts a,a. As the pulley revolves in the direction indicated by the arrow, the tendency is for the entire brake to rotate in the same direction; this is prevented by weights, P, in the scalepan suspended from the end of lever A. When the pulley runs at its normal speed, sufficient weight P is placed in pan to balance the lever between the pins e,e, which are provided to prevent the lever from revolving. The power absorbed by the clamp shoes c, d, is equal to the amount of work which is accomplished in foot-pounds per minute by the revolving shaft.

This work in foot-pounds $= N \times P \times L \times 2\pi$

The $H.P.$ $= \dfrac{2\pi\, NPL}{33000}$

The little pulleys F,F, and the weight W is provided as a counterbalance for the lever arm when machine is at rest.

The clamp shoes c and d should be well lubricated.

Example. — If an engine shaft makes 240 revolutions per minute, what is the $H.P.$ developed when a weight of 50 pounds is just balanced at the end of a 10-foot lever, as shown in Fig. 12?

Solution. —

$$H.P. = \frac{2\pi\, NPL}{33000} = \frac{6.2832 \times 240 \times 50 \times 10}{33000} = 22.9\, H.P.$$

WATER PRESSURE

Water stored in a tank exerts pressure against the sides, whether the sides are vertical, oblique, or horizontal. The force is exerted perpendicularly to the surface on which it acts.

The water pressure varies directly as the depth from the free surface.

This depth from the free surface is called the "head." Taking the weight of a cubic foot of water as 62½ pounds, the weight of a column of water 1 foot high and 1 square inch in cross section $= 62.5 \div 144 = .434$ pound.

Therefore, the pressure per square inch at any point in a body of water = the depth, in feet, below the surface, or the head $\times$ .434.

Then let P = pressure per square inch
H = head

Then $$P = H \times .434$$

and $$H = \frac{P}{.434}$$

To Find the Head when Pressure is given

Rule. — Divide the pressure by .434.

The following laws apply to liquids:

The pressure does not depend upon the size or shape of the vessel. The pressure increases with the depth below the free surface.

At any point in a liquid the upward, downward, and lateral (sideways) pressures are equal.

Lateral Pressure

To find the lateral pressure of water upon the sides of a tank, multiply the area of the submerged portion of the side in inches, by the pressure due to one-half the depth.

Example. — What is the lateral pressure on one side of a tank 20 inches long and 2 feet deep? (Fig. 13.)

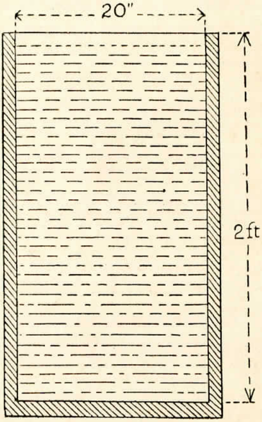


Fig. 13

Solution. —

$20'' \times 24'' = 480$ square inches = area of side.

$2' \times .434 = .868$ pounds pressure at bottom of tank.

$.868 \div 2 = .434$ pounds average pressure due to one-half the depth of the tank.

$.434 \times 480 = 208.32$ pounds = pressure on one side of the tank.

Capacity of Pipes

In computing the capacity of pipes used to convey liquids one should remember that the capacity varies with the area, and that the areas of similar figures vary as the squares of their corresponding dimensions.

Pipes being cylindrical in shape, are, therefore, similar figures. The areas of any two pipes are to each other as the squares of their diameters.

Example. — If one pipe is 6 inches in diameter, and another is 3 inches in diameter, their ratio is $\frac{36}{9}$ or $\frac{1}{4}$, and the area of the larger one is, therefore, 4 times the smaller one.

Approximate Method of Finding Relative Sizes of Pipes

This method is used for finding size of a pipe necessary to fill several smaller pipes. It is known many times as "Rule of Thumb Method," and is explained as follows:

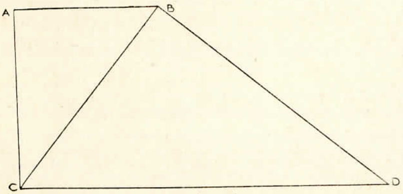


Fig. 14

To find the diameter of a pipe which will fill three pipes, having diameters of 2 inches, $2\frac{1}{2}$ inches, and 4 inches, respectively — Draw a right angle, (Fig. 14) one arm (AB) being 2 inches long, the other arm (AC) being $2\frac{1}{2}$ inches long. Draw a line from B to C. The length of this line (BC) is the size necessary for a pipe that will fill the two smaller pipes. From B and at right angles to BC, draw line BD, 4 inches long. Connect the points C and D. The length of this line (CD) will represent the size of a pipe necessary to fill the three pipes, having diameters of 2 inches, $2\frac{1}{2}$ inches, and 4 inches, respectively.

This process may be continued for as many pipes as desired.

GRINDING WHEELS

The term "grinding wheel" is applied to manufactured abrasive wheels which are usually run at high speed. The term "grindstone" applies to the natural stone wheels which are always run at low speed.

Grinding wheels are made from emery, corundum, carborundum, and alundum. The particles of whatever abrasive is used are held together by a bond.

Ordinary grinding wheels are generally run at a surface speed of about 5000 to 5500 feet per minute. Soft wheels, especially when used for grinding cutting tools, are run faster than hard wheels for the same purpose; but under no circumstances should the speed exceed 5500 feet per minute.

The speed of a wheel is found by multiplying the circumference by the number of revolutions per minute. If the circumference measure is in inches the answer obtained should be divided by 12 to change it to feet.

Example. — A grinding wheel 10 inches diameter makes 2100 revolutions per minute, how many feet is it running per minute?

Solution. — If it is 10 inches diameter the circumference will be $3.1416 \times 10 = 31.416$. $31.416 \times 2100 = 65973$ this being the number of inches it travels per minute. $65973 \div 12 = 5497$, the number of feet it is traveling per minute.

Wheels should be trued occasionally, to present sharp particles of cutting material, and also to keep them in balance. It is not safe to have a large heavy wheel run out of true.

WEIGHT OF METALS

1 cubic inch of cast iron weighs .2604 pounds
1 cubic inch of wrought iron weighs .2779 pounds
1 cubic nch of steel weighs .2834 pounds
1 cubic inch of copper weighs .3195 pounds
1 cubic inch of brass $\left.\begin{matrix}\text{copper } 65\\ \text{zinc } 35\end{matrix}\right\}$ weighs .3029 pounds
1 cubic inch of lead weighs .4106 pounds
1 cubic inch of aluminum weighs .0963 pounds.

Weight of Round Iron and Steel

The approximate weight of round bar iron or steel can be found by the formula,

$$L = \frac{(d \times 4)^2}{6}$$

where L = weight of one foot in length of the bar
d = diameter of the bar in inches.

While the above formula applies to the weight of round bars, the weight of square and rectangular bars may be found by computing their cubical contents in inches and multiplying this by the weight of 1 cubic inch. The answer will be the weight in pounds.

For the convenience of any who do not wish to work out the weight by the formula, the following table of weights per foot of length is given. The weight of a bar of any length may be found by multiplying the weight of one foot by the length of the bar in feet.

Diameter or Distance Across Flats	IRON Weight per Foot		STEEL Weight per Foot			
	Round	Square	Round	Square	Hexagon	Octagon
1/16	.010	.013	.010	.013	.012	.011
1/8	.041	.052	.042	.053	.046	.044
3/16	.092	.117	.094	.119	.103	.099
1/4	.164	.208	.167	.212	.185	.177
5/16	.256	.326	.261	.333	.288	.277
3/8	.368	.469	.375	.478	.414	.398
7/16	.501	.638	.511	.651	.564	.542
1/2	.654	.833	.667	.850	.737	.708
9/16	.828	1.055	.845	1.076	.932	.896
5/8	1.023	1.302	1.043	1.328	1.151	1.107
11/16	1.237	1.576	1.262	1.608	1.393	1.331
3/4	1.473	1.875	1.502	1.913	1.658	1.584
13/16	1.728	2.201	1.763	2.245	1.944	1.860
7/8	2.004	2.552	2.044	2.603	2.256	2.156
15/16	2.301	2.930	2.347	2.989	2.591	2.482
1	2.618	3.333	2.670	3.400	2.947	2.817
1 1/16	2.955	3.763	3.014	3.838	3.327	3.182
1 1/8	3.313	4.219	3.379	4.303	3.730	3.568
1 3/16	3.692	4.701	3.766	4.795	4.156	3.977
1 1/4	4.091	5.208	4.173	5.312	4.605	4.407
1 5/16	4.510	5.742	4.600	5.857	5.077	4.858
1 3/8	4.950	6.302	5.049	6.428	5.571	5.331
1 7/16	5.410	6.888	5.518	7.026	6.091	5.827
1 1/2	5.890	7.500	6.008	7.650	6.631	6.344
1 9/16	6.392	8.138	6.520	8.301	7.195	6.905
1 5/8	6.913	8.802	7.051	8.978	7.776	7.446
1 11/16	7.455	9.492	7.604	9.682	8.392	8.027
1 3/4	8.018	10.21	8.178	10.41	9.025	8.635
1 13/16	8.601	10.95	8.773	11.17	9.682	9.264
1 7/8	9.204	11.72	9.388	11.95	10.36	9.918
1 15/16	9.828	12.51	10.02	12.76	11.06	10.58
2	10.47	13.33	10.68	13.60	11.79	11.28

Diameter or Distance Across Flats	IRON Weight per Foot		STEEL Weight per Foot			
	Round	Square	Round	Square	Hexagon	Octagon
2⅛	11.82	15.05	12.06	15.35	13.31	12.71
2¼	13.25	16.88	13.52	17.22	14.92	14.24
2⅜	14.77	18.80	15.07	19.18	16.62	15.88
2½	16.36	20.83	16.69	21.25	18.42	17.65
2⅝	18.04	22.97	18.40	23.43	20.31	19.45
2¾	19.80	25.21	20.20	25.71	22.29	21.28
2⅞	21.64	27.55	22.07	28.10	24.36	23.28
3	23.56	30.00	24.03	30.60	26.53	25.36
3⅛	25.57	32.55	26.08	33.20	28.78	27.50
3¼	27.65	35.21	28.20	35.92	31.10	29.28
3⅜	29.82	37.97	30.42	38.78	33.57	32.10
3½	32.07	40.83	32.71	41.65	36.10	34.56
3⅝	34.40	43.80	35.09	44.68	38.73	37.05
3¾	36.82	46.88	37.56	47.82	41.45	39.68
3⅞	39.31	50.05	40.10	51.05	44.26	42.35
4	41.89	53.33	42.73	54.40	47.16	45.12

CHEMICAL SYMBOLS, SPECIFIC GRAVITY, WEIGHT AND MELTING POINT OF METALS AND COMPOSITIONS

Metal or Composition	Chemical Symbol	Specific Gravity	Weight per Cubic Inch Pounds	Melting Point
Aluminum	Al	2.56	0.0924	1200° F.
Antimony	Sb	6.71	0.2422	1150° F.
Barium	Ba	3.75	0.1354	1560° F.
Brass: 80C., 20Z		8.60	0.3105	1700° F. to 1850° F.
70C., 30Z		8.40	0.3032	
60C., 40Z		8.36	0.3018	
50C., 50Z		8.20	0.2960	
Bronze		8.85	0.3195	1675° F.
Cadmium	Cd	8.60	0.3105	610° F.
Calcium	Ca	1.57	0.0567	1450° F.
Chromium	Cr	6.50	0.2347	2740° F.
Copper	Cu	8.82	0.3184	1940° F.
Gold	Au	19.32	0.6975	1930° F.
Iron, cast	Fe	7.20	0.2600	2300° F.
Iron, wrought	Fe	7.85	0.2834	2900° F.
Lead	Pb	11.37	0.4105	620° F.
Magnesium	Mg	1.74	0.0628	1200° F
Manganese	Mn	7.42	0.2679	2200° F.
Mercury (60° F.)	Hg	13.58	0.4902	—39° F.
Molybdenum	Mo	8.56	0.3090	4500° F.
Nickel	Ni	8.80	0.3177	2600 F.
Platinum, rolled	Pt	22.67	0.8184	3200° F.
Platinum, wire	Pt	21.04	0.7595	3200° F.

Metal or Composition	Chemical Symbol	Specific Gravity	Weight per Cubic Inch Pounds	Melting Point
Potassium	K	0.87	0.0314	144° F.
Silver	Ag	10.53	0.3802	1740° F.
Sodium	Na	0.98	0.0354	200° F.
Steel	Fe	7.80	0.2816	2600° F.
Tin	Sn	7.29	0.2632	446° F.
Titanium	Ti	3.54	0.1278	3360° F.
Tungsten	W	18.77	0.6776	5400° F.
Vanadium	Va	5.50	0.1986	3200° F.
Zinc, cast	Zn	6.86	0.2476	785° F.
Zinc, rolled	Zn	7.15	0.2581	785° F.

COLORING STEEL

Bluing.

Small articles made of steel (such as screws, gun sights, tools not used for cutting, and various articles too numerous to mention) are blued. A very common method is to place the articles over the fire in an iron pan containing a quantity of clean dry sand. Move the pieces around constantly until they are of the desired color, then remove from the sand and plunge into clean oil. In coloring metals it is necessary to have the surfaces nicely polished and cleaned.

To Give Steel a Blue-black Color:

For many articles a *blue-black* color is preferable to a blue produced by heat alone. Melt together in a cast-iron dish 10 parts saltpeter and 1 part black oxide of manganese, and heat until a pine shaving or a little pine sawdust thrown on the surface will catch fire; but do not allow it to boil. Wire each piece of work and suspend in the mixture, making sure that every article is completely covered, and that they do not touch the retainer at any point. Allow them to remain until the desired color is obtained. Remove, wash in hot water, dry in clean sawdust, and oil.

To Give the Appearance of Case-hardening:

To 20 parts water add 1 part nitric acid. Immerse the

piece in the solution for about 30 seconds, remove, wash in clean warm water, and oil

To Imitate Case-hardening:

Wrought iron and low carbon steel may be given a mottled surface resembling nicely colored case-hardening, by melting in a cast-iron crucible a quantity of 50 *per cent fused* cyanide of potassium, heating the cyanide until it is red hot. Wire the work and suspend it in the liquid, allowing it to remain until it is red hot, when it should be removed and plunged in clean, cold water. Upon removing from the water the article should be dried and oiled.

Browning Steel

When browning gun barrels and articles having holes it is necessary to stop the ends of the holes with tightly fitting soft wood plugs. Clean the surface well with caustic soda solution to remove all grease and oil. Polish with fine emery cloth to produce a bright surface. Apply to every part of the surface, by means of a sponge or cloth attached to a stick, the following mixture: 1½ ounces sweet spirits of niter, 1½ ounces spirits of wine, 1 ounce sulphate of copper, ¾ ounce nitric acid. Mix and add the above to 1 quart of warm filtered water, and keep in a closed glass bottle for use. After applying the solution as described expose to the air for 24 hours, then remove the rust with a fine steel scratch brush. It will be necessary to make several applications of the solution. When the desired effect is obtained wash with boiling water, dry quickly, and oil by means of a cloth having on it a little linseed oil or white vaseline.

The wooden plugs referred to should project about 2 inches from the ends of the piece, and should be used in handling and to rest the work on when drying. If the articles are such that no plugs are used the operator should wear clean cotton gloves when handling, as finger marks will prove fatal to good results.

To Color Brass a Steel Blue

Dissolve 3 drams antimony sulphide and 4 ounces calcined soda in 1½ pints water. To this add 5½ drams

kermes. Filter and mix this solution with 5½ drams tartar, 11 drams sodium hyposulphite, and 1½ pint water. Polished sheet brass placed in the warm mixture will assume a steel blue color.

Olive Green on Brass

Mix together 8 parts copper sulphite, 2 parts sal ammoniac, 100 parts water. Boil and allow the articles to remain suspended in the solution until the desired appearance is obtained.

To Give Brass a Dull Appearance

Mix 1 part (by weight) of iron rust, 1 part white arsenic, and 12 parts hydrochloric acid. Clean the brass thoroughly and apply with a brush until the desired color is obtained, after which it should be oiled, dried, and lacquered.

Frosting Surfaces of Brass

Suspend the brass in a boiling solution of caustic potash, rinse in clean water, and dip in nitric acid till all oxide is removed; wash, then dry in warm sawdust, and lacquer while warm.

STRENGTH OF CHAINS

Chains made for hoisting weights are made from a good grade of wrought iron. The iron used in making chains has a tensile strength of from 40,000 to 48,000 pounds per square inch. Chains used for raising weights should never be made from steel, as it is not as strong under shock as wrought iron, and it does not weld as readily.

On account of the possibility of the weld not being as strong as the balance of the link, the strength of the chain is *not* reckoned as twice the strength of the bar from which it is made. When buying chain in the open market it is advisable to base our computations of strength on the lowest tensile strength of iron used for the purpose; *i.e.* 40,000 pounds to the square inch.

From numerous experiments it has been ascertained that the strength of a chain link is 1.63 times the strength of the bar from which it is made. The strength referred to is the breaking, or tensile, strength. And it is never

safe to strain to anywhere near the breaking point, because every time a piece of metal is strained to a point beyond its elastic limit it is permanently stretched and weakened. For this reason it is never considered advisable to strain a chain to more than one-half the amount shown by the method given for computing the tensile strength. In other words, the *proof test* of a chain should be about 50 per cent of the ultimate resistance of the weakest link.

Example. — What is the safe working strength of a chain made from ½-inch wrought iron whose tensile strength is 40,000 pounds per square inch?

Solution. —

Area = diameter square × .7854 = .5 × .5 × .7854 = .19635

.19635 × 40000 = 7854

7854 × 1.63 = 12802 pounds = ultimate breaking strength.

12802 × .50 = 6401 pounds = proof test, or safe working strength.

Open link chains are considered stronger than those having stud links. The latter are used under some conditions because they do not kink.

THE SCREW

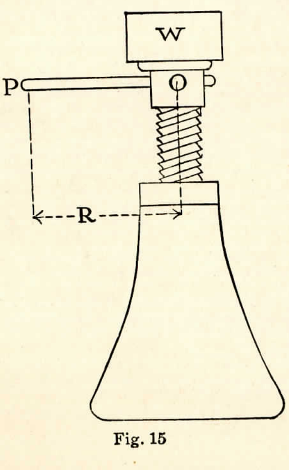


Fig. 15

The *screw* is extensively used in raising heavy weights through a short distance (Fig. 15).

When the screw is turned in its nut through one revolution, the nut being stationary the screw is moved a distance equal to the lead of the thread; the force (P) moves in the same time a distance equal to the circumference of a circle whose radius is the length of the lever (R) measured from the center of the screw. From this is obtained the rule.

Rule. — The force multiplied by the circumference of the circle through which the force arm moves is equal to the weight multiplied by the lead of the screw.

From this rule the following statement is obtained:

$$P : W = L : 2\pi R$$

Where
P = force
L = lead of screw
R = length of lever or wrench used
W = weight
π = 3.1416

then

$$P = \frac{W \times L}{2\pi R}$$

$$W = \frac{P \times 2\pi R}{L}$$

Example. — What weight will be raised with a screw of ¼-inch lead, when a force of 100 pounds is applied at the end of a lever 18 inches long from the center of screw?

$$W = \frac{P \times 2\pi R}{L} = W = \frac{100 \times 6.2832 \times 18}{.25} = 45239.04 \text{ pounds}$$

There is considerable loss in efficiency due to friction; the exact amount cannot be stated, as there are so many determining factors.

SOLDERING

Solders used for joining the surfaces or edges of pieces of metal are generally made of two or more metals alloyed together, and are generally divided in two classes, as follows, soft solder and hard solder. It must have a melting point lower than the metals to be joined by it, but in many cases it should approach very nearly that of the pieces to be united, as a stronger joint will result.

The so-called soft solders melt at lower heats than the hard, and are made by melting together tin and lead, although at times other materials are added to get a lower melting point.

Common soft solder is made from equal parts of tin and lead; fine solder, 2 parts tin to 1 of lead; cheap solder, 2 parts lead to 1 of tin.

The following table gives the composition and approximate melting points of a few soft solders:

Tin 1 to lead 10	540° F.	Tin 1 to lead 1	370° F.
Tin 1 to lead 5	510° F.	Tin 1½ to lead 1	335° F.
Tin 1 to lead 3	480° F.	Tin 2 to lead 1	340° F.
Tin 1 to lead 2	440° F.	Tin 3 to lead 1	355° F.

Success in soldering depends in a great measure on the care exercised in cleaning the surfaces, as solder will not adhere to a dirty or greasy surface. Fluxes are used to remove and prevent the further formation of oxide, as solder will not stick to an oxidized surface.

The flux more commonly used than any other is made by dissolving all the zinc scraps possible in a quantity of hydrochloric acid, adding the zinc a little at a time to the acid in a glass or earthenware vessel. As violent ebullition takes place, the vessel should be considerably larger than necessary to hold an equal volume of liquid. Add the zinc until the acid refuses to act on it, then add a saturated solution of sal ammoniac. Some makers add one-half the volume of the acid, others add an equal quantity, the exact amount depending on the idea of the user. This flux works well on brass, copper, tin, galvanized iron, wrought iron, steel, and zinc.

Muriatic (hydrochloric) acid is many times used for zinc, galvanized iron, and sheet iron. The acid, if strong, should be diluted with 25% water.

Tallow, rosin, and equal parts of rosin and oil are fluxes used for lead.

Surfaces scraped clean with a knife blade or similar tool take solder better than if cleaned in almost any other manner. Joints to be soldered should be closely fitted together. It is a mistake to suppose that an excess of solder means a strong joint.

Nonrusting Soldering Fluid.

While the zinc chloride soldering flux works nicely on steel, so far as soldering goes, it should not be used where there is danger of rust. A solution that will not cause rust is made by mixing 6 ounces alcohol, 2 ounces glycerine and 1 ounce oxide of zinc.

The soldering copper should be well tinned and heated somewhat hotter than the fusing point of the solder, but not hot enough to burn the tinning.

Solder will not flow *into* a joint and fill it, unless the metal is heated to the temperature required to melt the solder. This can be done by repeatedly passing the copper over the surface after solder has been deposited at the opening of the joint.

Sweating is the process whereby 2 or more pieces of metal are joined together by means of solder. Take, for instance, 2 pieces of steel, iron, or brass several inches long and of almost any thickness. First file or machine the contact surfaces perfectly flat, then heat the pieces until solder placed on the surfaces will melt, but do not heat enough to oxidize the metal; apply the flux and tin the surface by means of the soldering copper; apply more flux to the surfaces and clamp them together, then hold in the flame of a Bunsen burner until the solder between the pieces melts; remove from the flame and allow the work to cool.

ELECTRIC UNITS

The *volt* is the unit of electrical pressure.

The *ampere* is the unit of current strength or rate of flow.

The *ohm* is the unit of resistance.

The *watt* is the unit of power.

The *ohm*, *ampere*, and *volt* are defined in terms of one another as follows:

Ohm, the resistance of a conductor through which a current of *one ampere* will pass when the electro-motive force is *one volt*.

Ampere, the quantity of current which will flow through a resistance of *one ohm* when the electro-motive force is *one volt*.

Volt, the electro-motive force required to cause a current of *one ampere* to flow through a resistance of *one ohm*.

The relation which these quantities bear to one another is expressed by *Ohm's Law*.

$$\text{Current in amperes} = \frac{EMF \text{ in volts}}{\text{Resistance in ohms}}$$

Then $C = \frac{E}{R}$

where E = the electro-motive force in volts
R = resistance in ohms
C = current in amperes

The electric H. P. = 746 watts.

RELATIVE POWER OF DIFFERENT METALS TO CONDUCT ELECTRICITY

(Volumes of each being equal)

Silver = 100

Copper	97.67	Platinum	14.43
Gold	76.71	Iron	16.80
Silver	100.	Tin	14.39
Zinc	29.57	Lead	8.42

BOILING POINTS AT ATMOSPHERIC PRESSURE

FAHRENHEIT READINGS

	Degrees		Degrees
Aniline	363	Naphthalene	428
Alcohol	173	Nitric acid	248
Ammonia	140	Oil of turpentine	315
Benzine	176	Saturated brine	226
Bromine	145	Sulphur	833
Carbon bisulphide	118	Sulphuric acid	590
Ether	100	Water, pure	212
Linseed oil	597	Water, sea	213.2
Mercury	676	Wood alcohol	150

DECIMAL EQUIVALENTS OF PARTS OF AN INCH

1/64	.01563	13/64	20313	25/64	.39063
1/32	.03125	7/32	.21875	13/32	.40625
3/64	.04688	15/64	.23438	27/64	.42188
1/16	.0625	1/4	.25	7/16	.4375
5/64	.07813	17/64	.26563	29/64	.45313
3/32	.09375	9/32	.28125	15/32	.46875
7/64	.10938	19/64	.29688	31/64	.48438
1/8	.125	5/16	.3125	1/2	.5
9/64	.14063	21/64	.32813	33/64	.51563
5/32	.15625	11/32	.34375	17/32	.53125
11/64	.17188	23/64	.35938	35/64	.54688
3/16	.1875	3/8	.375	9/16	.5625

37/64	.57813	47/64	.73438	7/8	.875
19/32	.59375	3/4	.75	57/64	.89063
39/64	.60938	49/64	.76563	29/32	.90625
5/8	.625	25/32	.78125	59/64	.92188
41/64	.64063	51/64	.79688	15/16	.9375
21/32	.65625	13/16	.8125	61/64	.95313
43/64	.67188	53/64	.82813	31/32	96875
11/16	.6875	27/32	.84375	63/64	98438
45/64	.70313	55/64	.85938	1	1 00000
23/32	.71875				

FRENCH OR METRIC MEASURES

The metric unit of length is the metre = 39.37 inches.
The metric unit of weight is the gram = 15.432 grains.
The following prefixes are used for subdivisions and multiples: Milli = 1/1000, Centi = 1/100, Deci = 1/10, Deca = 10, Hecto = 100, Kilo = 1000, Myria = 10,000.

FRENCH AND BRITISH (AND AMERICAN) EQUIVALENT MEASURES

MEASURES OF LENGTH

French		British and U. S.
1 metre	=	39.37 inches, or 3.28083 feet, 1.09361 yards
.3048 metre	=	1 foot
1 centimetre	=	.3937 inch
2.54 centimetres	=	1 inch
1 millimetre	=	.03937 inch, or nearly 1-25 inch
25.4 millimetres	=	1 inch
1 kilometre	=	1093.61 yards, or .62137 mile

MEASURES OF WEIGHT

French		British and U. S.
1 gramme	=	15.432 grains
.0648 gramme	=	1 grain
28.35 grammes	=	1 ounce avoirdupois
1 kilogramme	=	2.2046 pounds
.4536 kilogramme	=	1 pound
1 tonne or metric ton 1000 kilogrammes	=	.9842 ton of 2240 pounds 19.68 cwt. 2204.6 pounds
1.016 metric tons 1016 kilogrammes	=	1 ton of 2240 pounds

MEASURES OF CAPACITY

French		British and U. S.
1 litre (= 1 cubic decimetre)	=	61.023 cubic inches .03531 cubic foot .2642 gal. (American) 2.202 lbs. of water at 62° F.
28.317 litres	=	1 cubic foot
4.543 litres	=	1 gallon (British)
3.785 litres	=	1 gallon (American)

TABLE OF DECIMAL EQUIVALENTS OF MILLIMETERS AND FRACTIONS OF MILLIMETERS

mm.	Inches	mm.	Inches	mm.	Inches	mm.	Inches
$\frac{1}{100}$	.00039	$\frac{33}{100}$	.01299	$\frac{64}{100}$	.02520	$\frac{95}{100}$	.03740
$\frac{2}{100}$	.00079	$\frac{34}{100}$	.01339	$\frac{65}{100}$	.02559	$\frac{96}{200}$	.03780
$\frac{3}{100}$	.00118	$\frac{35}{100}$	.01378	$\frac{66}{100}$	.02598	$\frac{97}{100}$	.03819
$\frac{4}{100}$	.00157	$\frac{36}{100}$	.01417	$\frac{67}{100}$	.02638	$\frac{98}{100}$	.03858
$\frac{5}{100}$	.00197	$\frac{37}{100}$	.01457	$\frac{68}{100}$	.02677	$\frac{99}{100}$	.03898
$\frac{6}{100}$	.00236	$\frac{38}{100}$	.01496	$\frac{69}{100}$	.02717	1	.03937
$\frac{7}{100}$	.00276	$\frac{39}{100}$	.01535	$\frac{70}{100}$	.02756	2	.07874
$\frac{8}{100}$	.00315	$\frac{40}{100}$	.01575	$\frac{71}{100}$	.02795	3	.11811
$\frac{9}{100}$	.00354	$\frac{41}{100}$	.01614	$\frac{72}{100}$	.02835	4	.15748
$\frac{10}{100}$	.00394	$\frac{42}{100}$	.01654	$\frac{73}{100}$	.02874	5	.19685
$\frac{11}{100}$	.00433	$\frac{43}{100}$	.01693	$\frac{74}{100}$	.02913	6	.23622
$\frac{12}{100}$	.00472	$\frac{44}{100}$	.01732	$\frac{75}{100}$	.02953	7	.27559
$\frac{13}{100}$	.00512	$\frac{45}{100}$	.01772	$\frac{76}{100}$	.02992	8	.31496
$\frac{14}{100}$	.00551	$\frac{46}{100}$	.01811	$\frac{77}{100}$	.03032	9	.35433
$\frac{15}{100}$	.00591	$\frac{47}{100}$	.01850	$\frac{78}{100}$	.03071	10	.39370
$\frac{16}{100}$	.00630	$\frac{48}{100}$	.01890	$\frac{79}{100}$	.03110	11	.43307
$\frac{17}{100}$	.00669	$\frac{49}{100}$	.01929	$\frac{80}{100}$	.03150	12	.47244
$\frac{18}{100}$	.00709	$\frac{50}{100}$	.01969	$\frac{81}{100}$	.03189	13	.51181
$\frac{19}{100}$	.00748	$\frac{51}{100}$	.02008	$\frac{82}{100}$	.03228	14	.55118
$\frac{20}{100}$	.00787	$\frac{52}{100}$	.02047	$\frac{83}{100}$	.03268	15	.59055
$\frac{21}{100}$	.00827	$\frac{53}{100}$	.02087	$\frac{84}{100}$	.03307	16	.62992
$\frac{22}{100}$	.00866	$\frac{54}{100}$	.02126	$\frac{85}{100}$	.03346	17	.66929
$\frac{23}{100}$	.00906	$\frac{55}{100}$	.02165	$\frac{86}{100}$	.03386	18	.70866
$\frac{24}{100}$	.00945	$\frac{56}{100}$	.02205	$\frac{87}{100}$	.03425	19	.74803
$\frac{25}{100}$	.00984	$\frac{57}{100}$	.02244	$\frac{88}{100}$	.03465	20	.78740
$\frac{26}{100}$	.01024	$\frac{58}{100}$	.02283	$\frac{89}{100}$	.03504	21	.82677
$\frac{27}{100}$	.01063	$\frac{59}{100}$	.02323	$\frac{90}{100}$	.03543	22	.86614
$\frac{28}{100}$	.01102	$\frac{60}{100}$	.02362	$\frac{91}{100}$	.03583	23	.90551
$\frac{29}{100}$	.01142	$\frac{61}{100}$	.02402	$\frac{92}{100}$	.03622	24	.94488
$\frac{30}{100}$	.01181	$\frac{62}{100}$	.02441	$\frac{93}{100}$	.03661	25	.98425
$\frac{31}{100}$	.01220	$\frac{63}{100}$	.02480	$\frac{94}{100}$	.03701	26	1.02362
$\frac{32}{100}$	.01260						

Long Diameter of a Square Figure

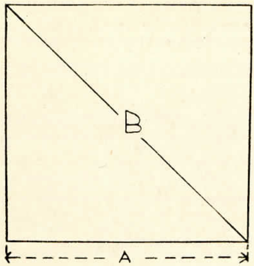


Fig. 16

It is necessary many times for the woodworkman to find the distance across corners of a *square* where actual measurement is not possible, and also for the machinist to find the distance across corners (long diameter) of a square head screw when the distance across flats (short diameter) is given, as in Fig. 16.

Rule. — Multiply the length *A* by 1.4142, and the product is the distance across corners (*B*).

Long Diameter of a Hexagonal Figure

Fig. 17 shows a hexagonal figure. *A* represents the short diameter, *B* the long diameter. If it is necessary to find the length *B* where *A* is known use the following:

Rule. — Multiply the length *A* by 1.1547, and the product is the distance across corners.

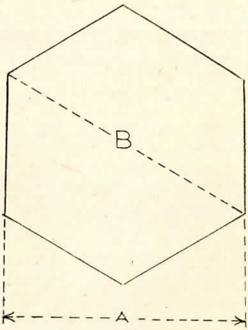


Fig. 17

To Find a Tap Size Drill

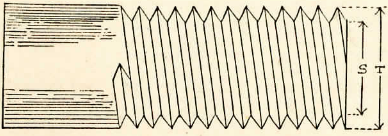


Fig. 18

A simple method of finding a tap drill for a V thread, or United States Standard thread tap, is provided by the following formulas, and will be readily understood by referring to

Fig. 18, where S = desired size
T = diameter of tap, or screw
N = number of threads per inch

For V-thread

$$S = T - \frac{1.733}{N}$$

For U. S. Standard thread

$$S = T - \frac{1.3}{N}$$

Example. — What is the tap size drill for a ¾ inch diameter 10 thread per inch V-thread tap?

Solution. —

$$S = T - \frac{1.733}{N} = S = \frac{3}{4} - \frac{1.733}{10} = S = .750 - .1733$$

$$= S = .5767 \text{ inch. Ans.}$$

TAP DRILLS

FOR V THREAD TAPS 9/32 INCH AND SMALLER

Size of Tap	No. of Threads	Size of Drill
1/16	60	No. 55
5/64	60	52
3/32	48	47
3/32	56	46
3/32	60	46
7/64	32	45
7/64	36	44
7/64	40	43
7/64	44	43
7/64	48	42
1/8	32	40
1/8	36	38
1/8	40	37
1/8	44	36
9/64	30	35
9/64	32	32
9/64	36	35
9/64	40	33
5/32	30	31
5/32	32	30
5/32	36	29
5/32	40	29
11/64	32	30
11/64	36	29
11/64	40	28
3/16	24	27
3/16	28	No. 26
3/16	30	23
3/16	32	23
13/64	24	21
13/64	28	20
13/64	32	20
7/32	22	19
7/32	24	18
7/32	28	17
7/32	30	15
7/32	32	13
15/64	22	10
15/64	24	10
15/64	28	9
15/64	32	9
1/4	20	7
1/4	22	5
1/4	24	2
1/4	32	2
17/64	18	4
17/64	20	2
17/64	24	3
17/64	32	1
9/32	18	2
9/32	20	1
9/32	24	1

TWIST DRILL AND STEEL WIRE GAUGE
SIZES OF GAUGE IN DECIMALS OF 1 INCH

No.	Size of Number	No.	Size of Number	No.	Size of Number	No.	Size of Number
1	.2280	16	.1770	31	.1200	46	.0810
2	.2210	17	.1730	32	.1160	47	.0785
3	.2130	18	.1695	33	.1130	48	.0760
4	.2090	19	.1660	34	.1110	49	.0730
5	.2055	20	.1610	35	.1100	50	.0700
6	.2040	21	.1590	36	.1065	51	.0670
7	.2010	22	.1570	37	.1040	52	.0635
8	.1990	23	.1540	38	.1015	53	.0595
9	.1960	24	.1520	39	.0995	54	.0550
10	.1935	25	.1495	40	.0980	55	.0520
11	.1910	26	.1470	41	.0960	56	.0465
12	.1890	27	.1440	42	.0935	57	.0430
13	.1850	28	.1405	43	.0890	58	.0420
14	.1820	29	.1360	44	.0860	59	.0410
15	.1800	30	.1285	45	.0820	60	.0400

LETTER SIZES OF DRILLS

Diameter Inches	Decimals of 1 Inch	Diameter Inches	Decimals of 1 Inch
A 15/64	.234	N	.302
B	.238	O 5/16	.316
C	.242	P 21/64	.323
D	.246	Q	.332
E 1/4	.250	R 11/32	.339
F	.257	S	.348
G	.261	T 23/64	.358
H 17/64	.266	U	.368
I	.272	V 3/8	.377
J	.277	W 25/64	.386
K 9/32	.281	X	.397
L	.290	Y 13/32	.404
M 19/64	.295	Z	.413

29° SCREW THREAD
ACME STANDARD

The various parts of the 29° screw thread, Acme Standard, are obtained as follows:

Width of point of tool for

Screw or tap thread $= \dfrac{.3707}{\text{thds. per in.}} - .0052$

Width of screw or nut thread $= \dfrac{.3707}{\text{thds. per in.}}$

Diameter of tap $=$ diameter of screw $+ .020$

Diameter of tap or screw at root $=$

$$\text{diameter of screw} - \left\{ \frac{1}{\text{thds. per in.}} + .020 \right\}$$

$$\text{Depth of thread} = \frac{1}{2 \times \text{thds. per in.}} + .010$$

TABLE OF THREAD PARTS

Threads per Inch	Depth of Thread	Thickness at Top of Thread	Width Space at Bottom of Thread	Space at Top of Thread	Thickness at Root of Thread
1	.5100	.3707	.3655	.6293	.6345
1⅓	.3850	.2780	.2728	.4720	.4772
2	.2600	.1853	.1801	.3147	.3199
3	.1767	.1235	.1183	.2098	.2150
4	.1350	.0927	.0875	.1573	.1625
5	.1100	.0741	.0689	.1259	.1311
6	.0933	.0618	.0566	.1049	.1101
7	.0814	.0529	.0478	.0899	.0951
8	.0725	.0463	.0411	.0787	.0839
9	.0655	.0413	.0361	.0699	.0751
10	.0600	.0371	.0319	.0629	.0681

TABLE OF DECIMAL EQUIVALENTS OF SCREW GAUGE FOR MACHINE AND WOOD SCREWS

The difference between consecutive sizes is .01316 inches for American Screw Company Standard; .013 inches for A. S. M. E. Standard.

No. of Screw Gauge	Size of Number in Decimals		No. of Screw Gauge	Size of Number in Decimals		No. of Screw Gauge	Size of No. in Decimals
	American Screw Co. Standard	A.S.M.E. Basic and Maxim'm Outside Diameter		American Screw Co. Standard	A.S.M.E. Basic and Maxim'm Outside Diameter		American Screw Co. Standard
000	.03152		16	.26840	.268	34	.50528
00	.04468		17	.28156		35	.51844
0	.05784	.060	18	.29472	.294	36	.53160
1	.07100	.073	19	.30788		37	.54476
2	.08416	.086	20	.32104	.320	38	.55792
3	.09732	.099	21	.33420		39	.57108
4	.11048	.112	22	.34736	.346	40	.58424
5	.12364	.125	23	.36052		41	.59740
6	.13680	.138	24	.37368	.372	42	.61056
7	.14996	.151	25	.38684		43	.62372
8	.16312	.164	26	.40000	.398	44	.63688
9	.17628	.177	27	.41316		45	.65004
10	.18944	.190	28	.42632	.424	46	.66320
11	.20260		29	.43948		47	.67636
12	.21576	.216	30	.45264	.450	48	.68952
13	.22892		31	.46580		49	.70268
14	.24208	.242	32	.47896		50	.71584
15	.25524		33	.49212			

MISCELLANEOUS INFORMATION

Rust Joint Cement, Quick Setting

1 part, by weight sal ammoniac
2 parts, by weight flour of sulphur
80 parts, by weight iron borings made into paste with water.

Rust Joint, Slow Setting

2 parts, by weight sal ammoniac
1 part, by weight flour of sulphur
200 parts, by weight iron borings made into paste with water.

This cement is better than that made by the first receipt, if the joint is not required for immediate use. When using either receipt the borings should be sifted in order to remove any but fine particles.

Rust Joint

To apply between flanges, or in similar places: Mix 10 parts of sifted iron filings, 3 parts chloride of lime, and enough water to make a fairly stiff paste. Place a thin layer between the flanges, bolt or clamp securely together and allow to stand for from 15 to 20 hours.

Cement to Resist High Heats

A cement that will resist the action of high heats may be made of fire clay 4 parts; iron filings, finely sifted and free from rust, 2 parts; peroxide of manganese, 1 part; plumbago, 1 part; sea salt, ½ part; borax, ½ part. Work to a stiff paste and use immediately. Apply heat gradually at first.

Cement for Filling Cracks in Castings

Mix dry 8 parts of clean cast-iron filings, 1 part sal ammoniac, and ½ part flour of sulphur; place in a dish and add 15 times the amount (by weight) of clean iron filings, or sifted iron borings; add water to form a stiff paste. The above mixture should be worked into the crack and allowed to dry.

Iron Putty

A good putty for steam joints is made by mixing dry 2 parts good metallic paint, 1 part litharge, 3 parts finely sifted iron filings. Mix to a stiff consistency with boiled linseed oil.

Plumbers' Cement

Black rosin, 1 part; brick dust, 2 parts. Keep at boiling heat and mix thoroughly.

To Glue Leather to Iron

Paint the iron with a coat of white lead and lamp black. To make cement, soak best quality of glue in cold water till soft, remove from the water, and dissolve in vinegar at moderate heat; add one-third of its bulk of white pine turpentine; stir until mixed thoroughly, then add vinegar until the mass is of proper consistency to spread with brush. Apply hot. Place the leather on quickly and press tightly to place.

Cement for Fastening Leather to Iron

Dissolve 1 part good glue in cider vinegar, add 1 ounce Venice turpentine. Place over a slow fire and allow to boil for 10 hours. It should be applied while hot, with a brush to the iron. The leather should be quickly placed on the iron and pressed firmly to place until dry. Whenever applying leather to iron by means of any cement it is necessary to thoroughly clean the iron. In some cases it is necessary to treat the surface of the iron with muriatic acid or acetic acid, to roughen it by rusting.

To Make a Hole in Hardened Steel

Melt a small quantity of wax and pour it on to the steel. Make a hole in the wax size of the hole desired. Then put a few drops of strong nitric acid in the hole and leave it for some time. If not eaten through in 15 or 20 minutes wash the acid off and apply another "dose." Continue this until the hole is eaten through.

To Drill Spring Tempered Steel

Make a *flat* drill of desired size. Harden it, and leave it dead hard. Proceed to drill in the ordinary way, using turpentine as a lubricant.

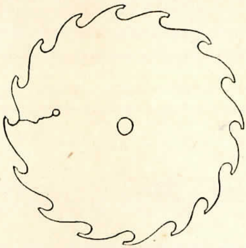


Fig. 19

To Stop a Crack in a Circular Saw

At the extremity of the crack drill a hole (Fig. 19). The crack will not go beyond. If a twist drill will not cut the metal, use a flat drill tempered very hard and lubricate with turpentine.

Inserting Wood Screws into End Grain of Wood

Wood screws inserted into the end grain, especially of soft wood, do not take a very strong hold. This trouble may be overcome by boring a hole through the piece, as shown in Fig. 20, at right angles to the screw hole and inserting a plug of hard wood into which the screw may be turned.

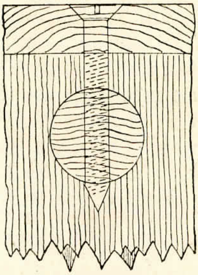


Fig. 20

To Find the Diameter of an Arc

At times it is necessary to find the diameter of an arc, or a portion of a circle; as, for instance, the diameter of a pulley when we have a portion of the rim.

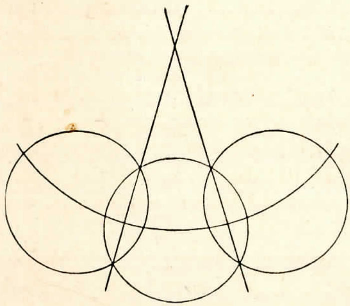


Fig. 21

Lay the broken piece on a clean, flat surface, scribe an arc as large as the piece will permit, then draw 3 circles, with the center of each on the arc, as shown in Fig. 21. Have the centers equidistant, with circles intersecting each other about ¼; draw two lines across the points of intersection of the circles, and the point where the two lines cross each other will be the center of the circle, or one-half the diameter.

MILLERS FALLS TOOLS

Tools Built to a Standard that Safeguards the Buyer

Wherever the sun shines, Millers Falls Tools are found. And Millers Falls Tools have earned their world-wide recognition and international reputation through just these three things: (1) Their quality. (2) Their many improvements. (3) Their guarantee.

Quality — adequate strength in every detail, attractive appearance, no unnecessary weight — these things have been watchwords with regard to every Millers Falls Tool made for the last half century. It is upon their quality that Millers Falls Tools have built up their reputation. It is quality that is *there.* It is dependable, it is actual, — it is tangible. You can tell it as soon as you examine any Millers Falls Tool critically or compare it with a similar tool of any other make.

And of as equal importance to you as the quality is the fact that Millers Falls Tools are a line of up-to-the-minute improvements. We maintain a corps of skilled inventors whose sole duty it is to perfect old designs to an ever-increasing point of efficiency and to invent new tools.

We back up the skill of our workmen with the best materials obtainable, — steels of the best quality known to modern science. As anything new is developed, it is tested to ascertain its adaptability to Millers Falls Tools, and if it proves better than what we have been using, it is henceforth adopted.

And to make sure that the quality ideal to which Millers Falls Tools are manufactured is in every Millers Falls tool that leaves our factory, every piece undergoes rigid inspection and trial. When you get Millers Falls Tools you get quality, — quality that can be *guaranteed,*

and guaranteed in a very definite and certain manner. We will make good on every reasonable complaint. We aim to make Millers Falls Tools *good* tools. We offer them to you as *good* tools. You buy them as *good* tools and your dealer sells them to you as *good* tools. If they do not prove so, we want to know it and make them *good* to you.

That is the kind of faith we have in our product. It is the making good on that faith that has put Millers Falls Tools in the position of first choice with experienced tool users the world around.

BIT BRACES

The steel brace of to-day, as shown in Fig. 22,is a wonderful example of the improvements made in tools in the last half century. It offers great contrast to the original wooden bit brace (Fig. 23) that many of the older mechanics even of to-day will recollect.

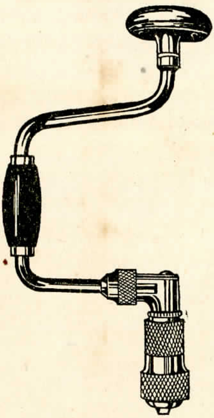


Fig. 22

It seems a strange commentary on the progressiveness of mechanics and workmen of fifty years ago, but it is a fact when the Millers Falls Company brought out the original "Barber" or iron brace in 1865, mechanics were so wedded to the old-fashioned wooden braces that it required considerable argument to convince them of the superiority of the metal one. The attitude of the modern mechanic is very different, being constantly on the lookout for any improvements in tools which will make his work easier.

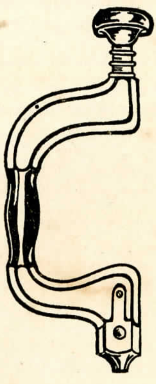
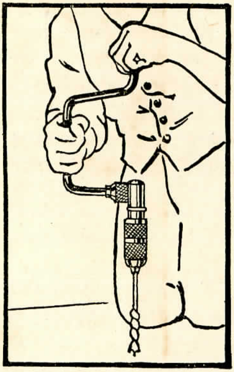


Fig. 23

The first Barber brace was made of malleable cast iron

and was a big improvement over the old wooden bit brace, but, as compared with the modern steel brace, it was crude in many respects; for instance, the handle in the sweep was simply a bulge in the metal.



The requirements of different work make necessary many styles of braces. The most complete line on the market is made by the Millers Falls Company, consisting of 254 different bit braces. These range all the way from very simple braces, such as would be suitable for use on ordinary odd jobs around the house, to the types which are found in the hands of the finest mechanics, made with precision, with chucks adapted to many different sizes and types of drills, and possessing many labor and time-saving devices and attachments.

Braces are made with various sweeps, the term "sweep" meaning the diameter of the circle described by the handle when in use. For light work a brace with an 8 inch sweep will prove more satisfactory than the larger sweep, as it permits faster work; but for general work, where power is necessary, a 10, a 12, or a 14 inch sweep is better. Of course the larger the sweep the greater the power exerted upon the bit.

Frequently ball bearings are placed in bit braces to offset loss of power from friction. Ball bearings increase the ease of operation to a remarkable degree and hence make more rapid work possible without increased exertion on the part of the mechanic. The more fully equipped a brace is with ball bearings, the better. This is an advantage often underrated.

Many braces are equipped with ratchet devices, so that they may be used in close quarters where only a portion of a circle can be described with the sweep, as when working next to a wall or in a corner.

Mechanics using a bit brace to any extent will find

Millers Falls "Lion" ratchet brace one peculiarly well adapted to their needs. Of this style, Series No. 770 has ball bearings in both handle and head. The ratchet is of the boxed type with exposed dogs. Series No. 870 is refined further by ball bearings in the sweep handle and the ratchet mechanism is fully concealed.

The chuck is provided with ball bearings, which greatly increase its gripping power. It will hold either round or square shank tools, adapting itself to either automatically. Although it holds tools firmly, it will not bind on itself, and can be readily released with a backward twist of the hand. If you use a bit brace, it will pay you to look at a Millers Falls "Lion" before making a purchase.

DRILL BRACES

When a drill point is used in a bit brace, the swing of the sweep tends to cause the drill to oscillate, or "weave," so that the drill cuts a hole larger than itself, or, if the drill has any "play" at the chuck, the hole is apt to be many sided instead of round. The drill brace obviates these troubles.

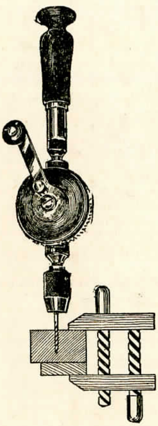


Fig. 24

In close quarters, where it would be impossible to use a bit brace in any other way than as a ratchet brace, the drill brace can be used to special advantage when using comparatively small drills, as owing to the combination of gears the drill can be driven at a speed many times faster than would be possible when ratcheting the brace.

The drilling attachment is removable, and the brace may be regularly used as an ordinary bit brace.

HAND DRILLS

The ordinary bit brace is too large and heavy to use with small drill points, as it is apt to cause them to break. The small hand drill, a common type of which is shown in Fig 24, is very light, and as it can easily be held rigidly, so that it will not "weave" or oscillate, its breakage of small

drills is almost negligible. The driving mechanism of the hand drill is geared up, permitting the operator to drive small drills at a high rate of speed. Frequently provisions are made for changing the gear ratios on hand drills, giving both a high speed and a low speed, changeable at will.

On all Millers Falls hand drills the gears have machine-cut teeth, giving the smoothest possible running motion and ease of operation. Many of the Millers Falls models are provided with ball thrust bearings. For convenience in cramped quarters and in doing delicate work, several of the Millers Falls models are provided with a simple and effective ratchet which operates in either direction. The handles of many of these models are made as receptacles for carrying an assortment of drills.

You will frequently find that many skilled workmen have two and even three sizes of hand drills to prepare them for a great variety of work.

BREAST DRILLS

It is frequently necessary to drill holes with a larger drill than the ordinary hand drill has the power to drive. When the work can be easily carried to a drill press, it is better to do so; but in case it cannot be removed, the breast drill is usually the easiest solution of the difficulty. In principle of operation a breast drill is generally similar to the hand drill, but it is larger and stronger and is provided with a breast plate, or shoulder cap, against which the workman may lean his weight to assist the drill.

Fig. 25

It is sometimes necessary to drill a hole in an inaccessible location, such as in the bed of a machine where projecting parts make it impossible to operate a breast drill with a drill of the ordinary length. Under such conditions, the extension bit holder with chuck, as shown in Fig. 25, may be used.

Workmen who find it necessary to drill large holes with a breast drill will appreciate the advantage of the auxiliary breast plate which is provided with Millers Falls breast drills. This auxiliary plate distributes the pressure over larger

area. It can be clamped on or removed, and may be turned at different angles, so as to assure the greatest comfort to the workman.

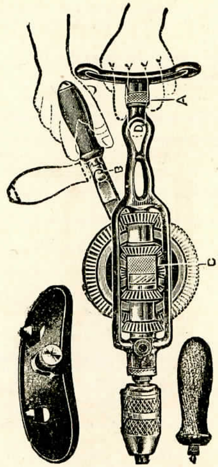


Fig. 26

The type of breast drill which has proved extremely popular with mechanics is Millers Falls No. 97, illustrated in Fig. 26. This drill is provided with readily adjustable ratchet so that it can be used in cramped quarters. The ratchets permit the chuck to revolve in the desired direction, whether crank be moved forward or backward.

Another unique feature is found in the handle, which may be placed at either right angles or swung into a straight line with the crank. In this latter position it provides greater leverage, and consequently more power. Another advantageous feature is the finger ring provided near the shoulder of the frame, which enables the operator to hold the tool firmly in positions where it cannot be rested against the body.

RATCHET DRILL

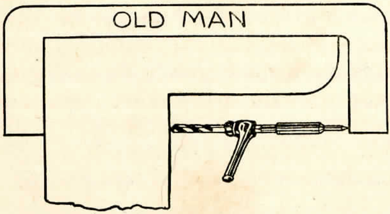


Fig. 27

While the ratchet drill is subject to limitations, there are a number of jobs of drilling where nothing else can be used. It is necessary sometimes to drill where there is no holding space for the chain of a chain drill and where there is not room enough to use a breast drill or a hand drill. In such a case the ratchet drill may be advantageously used. First, the feed screw should be turned in as far as it

will go. Then the drill point is placed in position and blocks of wood or metal are placed between the adjusting screw and the nearest solid part of the machine, wall, or foundation. Sometimes an "old man" of the style shown in Fig. 27 may be used to clamp the ratchet drill to its work.

When it is necessary to drill a number of holes in similar locations, a ratchet drill used in connection with a drilling post of the type shown in Fig. 28 provides a sure and rapid way and means of doing the work.

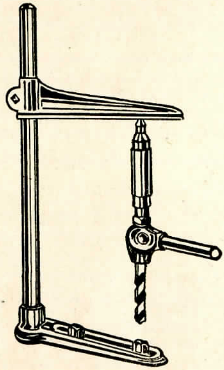


Fig. 28

CHAIN DRILLS

The chain drill is used as an auxiliary to the breast drill in cases where power required to feed the drill into the work is greater than that which the workman would be able to give. The chain drill may be used in many places where it is not possible to use the ratchet drill. In use, the chain is placed around the piece which is to be drilled and drawn tight with the drill in place. The chain drill may be used with a bit brace, or with a wrench attached to the square shank, or it may be operated by a ratchet drill.

Chain drills are especially useful in drilling steel rails, girders, structural ironwork, columns, pipes, and many machine repairs. The cutting tool may be fed by hand or automatically. The Millers Falls Company make seven different chain drills, furnished both with and without chucks. There is also a chain drill-breast drill combination and a combination brace-and-chain drill. The *adjustable* automatic feed of Millers Falls chain drills is especially important, as it reduces drill breakage to a minimum.

Chain drills equipped with ball bearings are especially desirable on medium size and large work, as they reduce friction and make all of the workmen's strength effective in actual drilling.

DRILL POINTS AND DRILLING

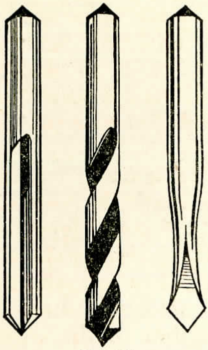


Fig. 29

For boring small holes in wood, iron, brass, or other materials, drill points are used. These points are made in three forms, as follows: flat drills, straight fluted drills, and twist drills. These three types are shown in Fig. 29.

The flat drill can be used for almost any material, but it does not cut as rapidly as either of the others. It is best suited for use on thin metals and on tile.

The straight fluted drill can be used advantageously on wood and the softer metals. It is especially satisfactory for drilling holes all the way through a piece of material, as it has no tendency to "draw-in" when breaking the hole through.

The twist drill is the most rapid cutter of the three and is especially desirable when working on very hard woods or heavy metals and for work where a deep hole is to be drilled. The twist drill, besides presenting a cutting edge at the point, carries the chips up to the surface preventing clogging. It is therefore unnecessary to remove a twist drill from the hole to clear it of chips.

When it is necessary to drill all the way through a piece of material, and when it is desired to have the cut clean and finished on both sides, it is advisable to clamp a piece of hard wood to the back of the piece which will be drilled, so as to support it and prevent breaking away when the drill comes through.

When a very large hole is to be drilled, it is sometimes easier to drill a smaller hole first in the exact center where the large one is wanted, and then to follow this up with a larger drill of the desired diameter. This not only relieves a great deal of the pressure and friction which makes the drilling of large holes difficult, but exactly centers the larger hole.

HACK SAW FRAMES

So common are the uses of hack saws that you will very seldom find a master workman's kit — whether he be carpenter, machinist, plumber, repairman, or general jobber — which will not have one and a supply of blades. It is a handy tool for the man who tinkers around the house, but it should not be used for the purpose of the ordinary saw.

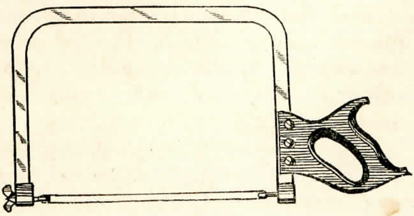


Fig. 30

Hack saw frames are made in various patterns and lengths, and, generally speaking, the size should be selected that is adapted to the work that one has to do. For certain purposes, such as rail cutting, a comparatively high frame, as shown in Fig. 30, is desirable. For all around work, however, one that is adjustable to various lengths is the best purchase. It should be borne in mind, however, that the frame should always be strong enough to resist the tendency to bend when in use, for if it does bend the blade will buckle and is almost sure to break. In buying it is wise to select a hacksaw that has more strength than is necessary.

The Millers Falls Company makes a number of hack saw frames of the adjustable type as well as those of fixed lengths. Some have fixed handles and others adjustable handles, while the latest innovation is the *pistol grip* handle. The ordinary form of handle answers well for light work, or where the saw is used but infrequently, but for heavy cuts or regular, frequent use the pistol grip will be found more satisfactory, as it allows the hand to assume its natural position, thus eliminating strain on the muscles of the hand and forearm.

When it is necessary to cut a strip from the edge of a sheet of metal the saw clips should be turned at right angles to the frame, thus enabling the operator to cut a strip of any desired length and of a width up to the full capacity of the frame.

HACK SAW BLADES

The older mechanics will recall readily when the only hack saw blade on the market was the Stubbs. On account of the high price these blades were sharpened again and again by filing the teeth in the same manner that saws used for wood are sharpened; and as one saw usually answered for a number of men in a shop, it was seldom sharpened until it was so dull it was impossible to use it longer. As these blades were of much harder metal than the saws used for cutting wood, it was not exactly a privilege to have to sharpen one; on the contrary, it was the hardest kind of work.

The "Star" hack saw blade — made by the Millers Falls Company, — is probably one of the best known blades in the world. They are used literally *wherever the sun shines.* The endeavor has been at all times to make the "Star" the best blade on the market. To accomplish this, the Millers Falls Company has experimented with various grades of steel, has taken advantage of every advance in the steelmakers' art. "Star" blades of to-day are made of a special Tungsten steel, very hard and very tough. These blades are sold at a price so low that they make it poor economy to use a dull blade and make resharpening entirely impractical. In both cutting quality and length of service "Star" blades are unequalled.

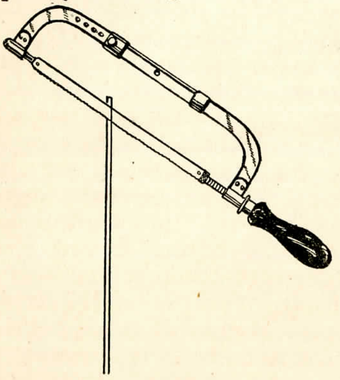


Fig. 31

Just as one type of wood saw is not adapted to every kind of work, so, too, hack saw blades should be chosen for the particular kind of work they are to do. For cutting thin pieces, such as sheet metal or tubing, a fine blade having 24 teeth tothe inch should be used. It is not good practice to cut directly across the sheet but at an angle, as shown in Fig. 31. This gives greater area of cut

and prevents stripping the teeth. For ordinary work, blades having 14 teeth to the inch are commonly used. Fine blades should *not* be used for cutting thick metals, as the chips are apt to clog and break the saw.

Always bear in mind when using a hack saw that the blade should be strained sufficiently tight in the frame to prevent buckling when pressure is applied in the operation of cutting. Also remember that it is necessary to bear down *only* on the *cutting* stroke and then only enough to make the teeth take hold. Do not bear down on the return stroke or the teeth will dull more rapidly than is necessary.

GLASS CUTTERS

To the glazier a good glass cutter is an absolutely indispensable tool, but the carpenter and the ordinary man-about-the-house as well finds a good glass cutter very convenient, despite the comparatively few times its use may be necessary. It is one of those tools that when you want it you want it *badly*, and nothing else will take its place.

To cut glass successfully, make sure that it lies on a perfectly flat surface, as otherwise the pressure of the glass cutter may cause it to crack. A "straight edge" is essential to a straight cut. The straight edge should be held firmly so that it cannot slip. A good way to hold it is to place the thumb and the little finger of the left hand on the glass and hold the straight edge to them with the first, second, and third fingers.

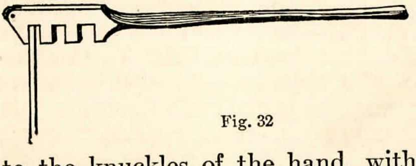


Fig. 32

The best way to hold the glass cutter is between the first and second fingers of the right hand, letting it rest close to the knuckles of the hand, with the first and second fingers firmly holding the flattened portion of the handle against the thumb. If the glass is dirty or greasy, wipe it with a rag where it is desired to cut. It is necessary to apply only sufficient pressure to the cutter to produce an

even, clean scratch. It is not advisable to pass the cutter twice over the one cut, as the fine particles of glass left by the first cut will dull the wheel. If the cut has been made evenly, the border can usually be broken off safely with the fingers, beginning at the edge nearest you. In case the border is narrow, it can be nipped off with the teeth of the breaker, as shown in Fig. 32.

Glass cutters are made both single roll or turret-head, multiple roll. Usually the difference in price between the two is small when the number of rolls on the turret type is considered. For this reason, even though the cost of the turret cutter is higher, it is the more economical in the long run.

MITER BOXES

If a workman intends and desires to do good joining work he cannot succeed unless he has a good miter box,—one that is accurate in its angles. A box that is "off" is bound to put a man in the way of blunders. When selecting a tool of this kind the points to be considered are these:

Is it easily adjustable?

Is it absolutely dependable?

Can it be easily and quickly set to any desired angle?

Is its control mechanism such that it can be set to a given angle any number of times and produce cuts that will measure up alike?

Can the clamping device be securely locked in any desired position?

Can the depth of cut be readily controlled?

Is the saw accompanying the box adapted to it in size?

Has it a length gauge for duplicating the length of pieces?

If the miter box you have measures up to all these specifications, you can rest assured that you have one which will give you complete satisfaction under every condition of work.

The Langdon miter boxes, made by the Millers Falls Company, answer all of these specifications and are made for lasting service. Langdon miter boxes made fifty years ago are frequently encountered and still doing excellent work.

In the preceding pages some of the common tools and their correct uses have been described and explained. Mention has been made of a few of the many Millers Falls Tools. Nowhere near a complete list of them has been attempted. The present line of the Millers Falls Company includes more than 125 different tools and machines comprising the list given below.

When you buy your tools make it a point to look for the Millers Falls trade-mark. It is your guarantee of the quality that insures a long lifetime of satisfaction in the using.

Angular bit stocks
Angular drilling machine
Anvil, vise, and drill
Anvils
Auger handles
Automatic boring tools
Automatic screw drivers
Awl, Crispin's
Barber lathe chuck
Bench drills
Bench hooks
Bit braces
Bit extensions
Bit gauges
Boring machines
Brace extensions
Breast drills
Butcher saw blades
Butcher saw frames
Carving tools
Chain drills
Chisel grinder
Chucks
Companion lathe and saw
Coping saws
Corner brace
Cricket fret saw
Drill braces
Drilling machines
Duplex screw drivers
File handles
Fret saw blades
Fret saw frames
Fret saw sets
Glass cutters
Goodell lathe and saw
Grindstones
Hack saw blades and frames
Hack saw machines
Hand drills
Hand drill presses
Hand vises
Hollow augers
Iron levels

Jack screws
Jewelers' saws and blades
Jointer gauge
Joist tools
Kitchen saw
Lathe chucks
Lathes
Master lathe chuck
Mechanics' vises
Miter boxes
Miter planers
Nail pullers
Offset vise and drill
Oval slide vises
Railroad vise
Ratchet drills
Ratchet screw drivers
Rogers fret saw
Screw driver bits
Screw drivers
Sill borer
Soldering sets
Spoke shaves
Spoke trimmers
Tool holders
Turning saws
Vises
Wagon jacks
Wagon wrench

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